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POWER

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The Ready-to-Wear World

TIME was when the consumer made or at least maintained and repaired most of the things that he used.

The housewife spun and wove fabrics for bed and table coverings and for clothing. The men built their own houses and made many of their own tools.

Everybody could turn his hand to something to keep things going.

Today all the essentials and most of the non-essentials are handed to the user ready for use, and he knows nothing about their making or maintenance, and often not enough to use them intelligently.

Once, when man wanted water he went to a well that he himself had perhaps dug and drew it, and if anything was the matter with the well or any of the toting apparatus, he fixed it.

Today he turns on a tap, one for hot water another for cold, and if anything goes wrong with it he sends for a plumber.

Our forebears used to put in their winters getting in cordwood, and there was always employment for any leisure that they might have in reducing it to stove wood, kindling or chunks for the fireplace.

Today we turn on a radiator to get warm and turn on the gas or electricity to do the cooking; and if they don't work, we call the janitor.

In the old days they raised their grain and had it ground, raised and butchered their pigs, sheep and cattle, stored, dried or canned their own fruits and vegetables.

Today they are handed out to us in sealed cartons, "untouched by human hands."

The proudest product of the old-fashioned housewife was her cooking—stacks of "riz bread," rows of pies, loaves of "sweet cake," crocks of doughnuts and cookies.

Today they come done up in paraffined paper and we buy them by the loaf, piece, dozen or pound at the bakers or delicatessen.

Dad used to harness the team to drive to town, and there was nothing about it that he could not fix, from a colicky horse to a broken harness.

Today we hop into an auto and step on the gas, and not one in a thousand of us knows what makes it go when it does go or what is the matter when it does not.

F. R. Low

Burning Pulverized Lignite In a Texas Power Plant

By L. H. Morrison

An account of the coal-handling equipment of the Trinidad plant of the Texas Power & Light Company—Results obtained with pulverized lignite—Operating Experiences in drying and handling the fuel

IN SPITE of the enormous deposits of lignite coal in Texas most of the power plants in the state burn fuel oil or natural gas. Many plants are justified in doing this since the boiler-room equipment necessary to burn lignite successfully is expensive, but both stokers and pulverizing equipment have proved successful with lignite, and for large developments the savings from the use of lignite, if transportation costs are low, may well justify the necessary equipment for burning solid fuel. This has been the experience of the Texas Power & Light Company in the operation of its Trinidad, Texas, plant.

Texas lignite yields an analysis somewhat as follows: Fixed carbon, 35.93 per cent; volatile, 21.10; sulphur, 0.48; ash, 9.16; moisture, 33.39 per cent. Heat value, 7,069 B.t.u. per lb.

Moisture a Detriment

It is at once obvious that the heavy percentage of moisture is a detriment both to high ratings and to boiler efficiency under usual firing conditions. When the boilers are hand-fired, the loss of combustible through the grates is high and the same trouble has been experienced with stokers when these were not suitable for lignite. Air spaces in grates must be small to avoid sifting, for the lignite air slacks very quickly and will not stand handling without crumbling or "dusting."

Pulverizing the fuel was suggested long ago, but it was believed that the large amount of water in the lignite would clog up any feeder device and by its chilling action prevent the attainment of suitable furnace conditions. That these difficulties were imaginary is proved by the results obtained at the 40,000-kw. Trinidad Station of the Texas Power & Light Company.

This plant produces a kilowatt-hour at the switchboard with an expenditure of 17,800 B.t.u., equivalent to slightly over 2½ lb. of lignite. This efficiency by no means compares with that of many other plants, but by reason of the low cost of the lignite delivered at the station the fuel cost per kilowatt-hour is lower than that of many more efficient coal-burning plants. The boiler room efficiency is only moderate—about 75 per cent—one of the major losses being due to the moisture in the fuel. The economics of the case warranted the use of neither air preheaters nor economizers.

The lignite is mined eight miles from the Trinidad plant, both shaft and strip processes being followed. The lignite coal is hauled to the plant in standard dump-bottom cars, and if not needed immediately, the cars are set on a storage track a short distance from the plant. From this point a storage-battery locomotive shifts the car to the plant, where the lignite is weighed and dumped into a track hopper. This hopper is 32 ft. long and 13 ft. wide, with sides sloping to two openings at the bottom, out of which the coal flows to apron conveyors located in the brick tower shown in Fig. 1. These are 30 in. wide and, when traveling at 18 ft. per min., deliver 100 tons of lignite each to the crushing equipment. This latter consists of two sets of 24x50-in. single-roll crushers, each set embracing two crushers with a vibratory screen between. When discharged from the lower element, 95 per cent of the lignite will pass through a 0.75-in. mesh, but operation with a 1½-in. mesh has been found more satisfactory.

Bucket Conveyors Lift the Crushed Lignite

Bucket conveyors, these being in duplicate, lift the crushed lignite to the top of the crusher house and dump it on two inclined-belt conveyors which run into the main building. Here the lignite is discharged on a second belt conveyor running over the lignite storage bins. All this lignite-handling equipment is in duplicate and is arranged so that either elevator can discharge to either belt conveyor.

The lignite passes directly from the bin down through the driers into the pulverizing mill. Each of the driers consists of four stacks of 45 steam grids through which the coal drops on its way to the mills. The grids are in all essentials similar to a steam radiator, and steam is supplied at 10 lb. gage pressure from the 7-stage bleeder line from the main turbine. A connection is also made so that saturated steam from the boiler can be used in emergency. Air is drawn through the driers by a fan that exhausts into a cyclone, where the lignite dust is

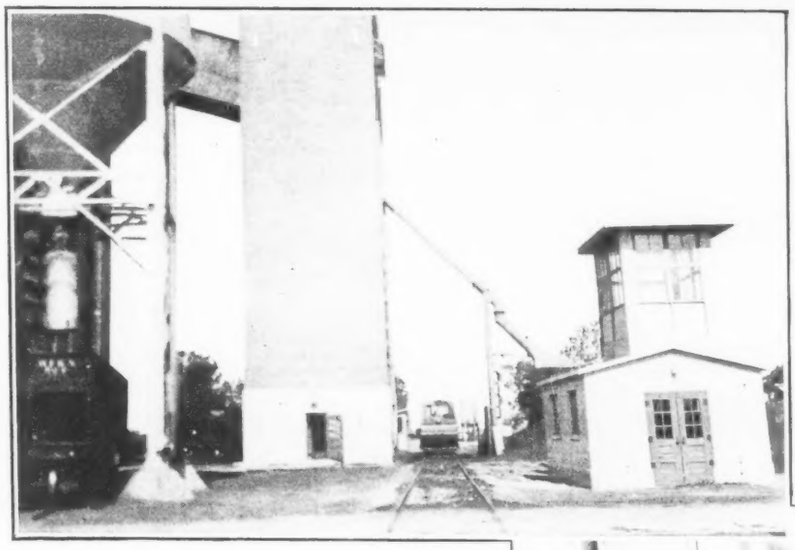
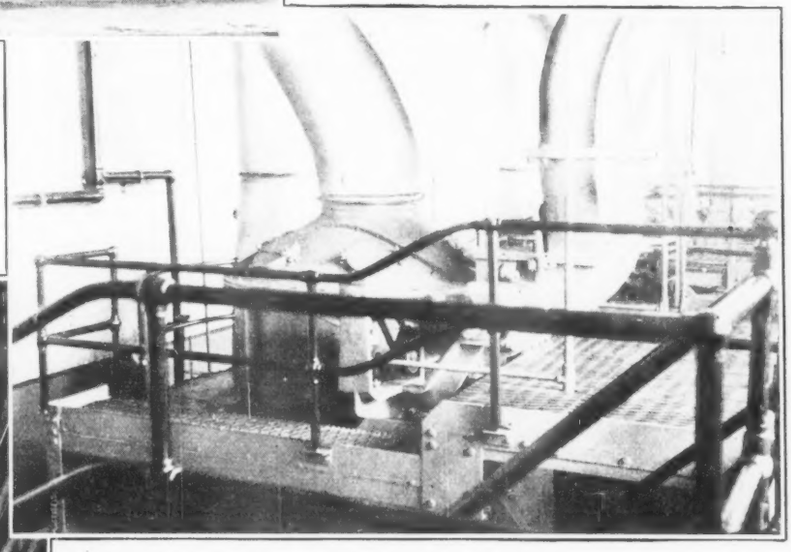


Fig. 1 (Left)—Coal crushers and elevators are in the brick towers

Fig. 2 (Right)—Four pulverizing mills are installed in the basement



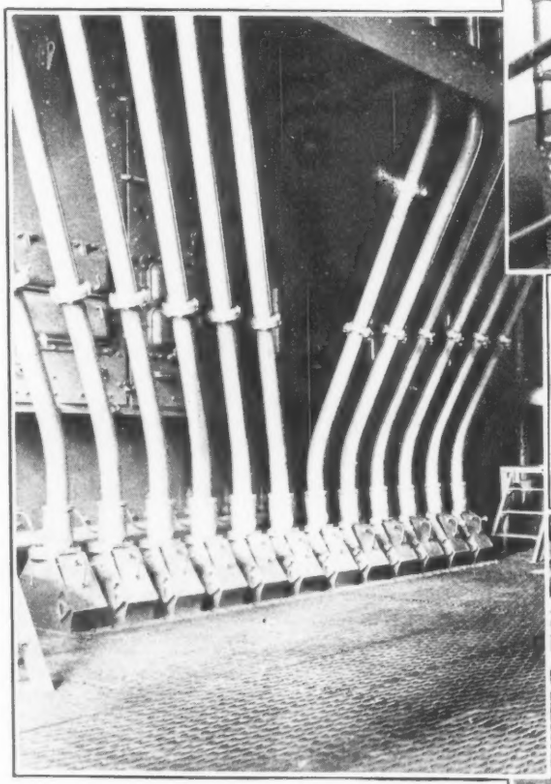


Fig. 3 (Left)—Feed lines and burners on one of the boilers

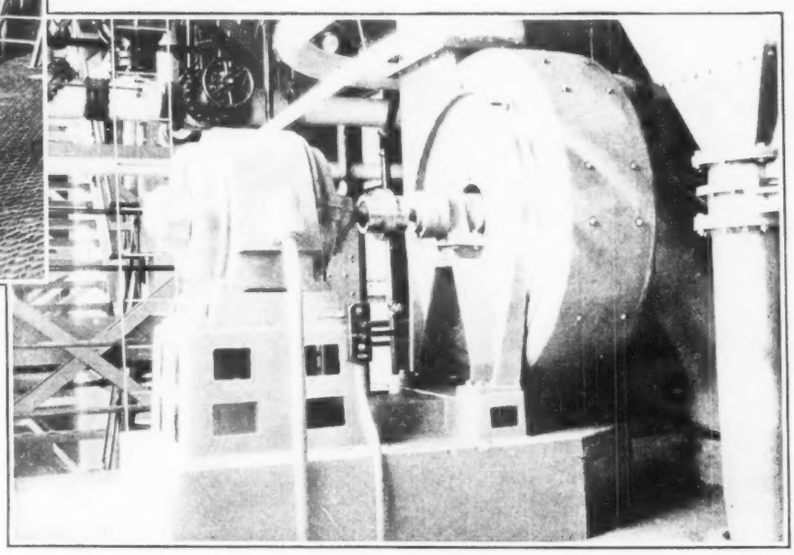


Fig. 4 (Right)—One of the fans handling pulverized lignite

removed and dumped into a screw conveyor, there being a cyclone for each drier.

There are four 15-ton Raymond mills in the basement, as shown in Fig. 2. The pulverized lignite is drawn out of each mill by an individual exhauster fan and discharged into a cyclone located at the top of the building above the raw-lignite belt conveyor. The fuel is discharged from the cyclone into either of two long 16-in. diameter screw conveyors running lengthwise of the bins, which discharge into either of two cross-screw conveyors. These latter conveyors dump the fuel into two screw conveyors running over and discharging into the powdered fuel bins above the boilers.

From the bin over the individual boiler twelve screw feeders deliver the fuel to the Lopulco burners, of which there are twelve per boiler; the burner piping of one boiler is shown in Fig. 3. The burners discharge vertically downward into the furnace. A flat arch under the mud-drum end of the boiler extends the furnace out far enough to permit openings for the burners, which are spaced 16.5 in. apart with the end burners 4 ft. from the side walls. The front wall and the portion of each side wall under the boiler are water cooled, with the arch portion cooled by the secondary air.

Each boiler has 18,756 sq.ft. of heating surface, while the water walls give 2,520 sq.ft. additional surface. The furnace is 24 ft. square by 39.5 ft. high, and the water screen tubes are 4 ft. from the bottom. The furnace has a volume of 18,530 cu.ft. above the water screens, or approximately 0.6 cu.ft. per sq.ft. of total heating surface.

The primary air is handled by fans placed in the basement under the boiler settings, the air being drawn from around the ashpits. In operation the plant has met every major expectation of the designers so far as plant efficiency and continuity of service are concerned, although a few operating problems were encountered.

The steam driers were intended to remove enough water to reduce the moisture content to perhaps 18 per cent. This, however, has not been secured in practice. By the combination of steam drying and mill circuit drying it is possible to remove about 5 per cent; of this 2 per cent is removed in the driers and the rest in the mill circuit. Some of the drier grids did not at first heat up, which permitted part of the coal to pass through without drying. This difficulty was overcome by installing individual traps on the grids in sections of seven and by minor changes in piping.

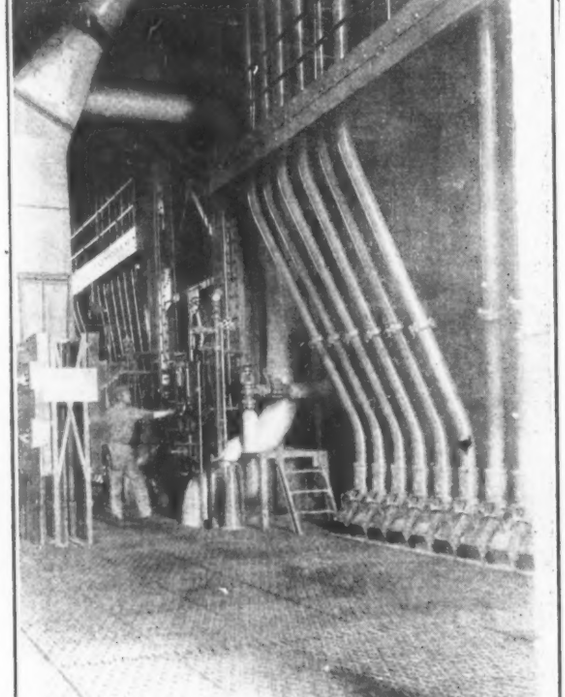


Fig. 5—Fronts of two boilers and the control board

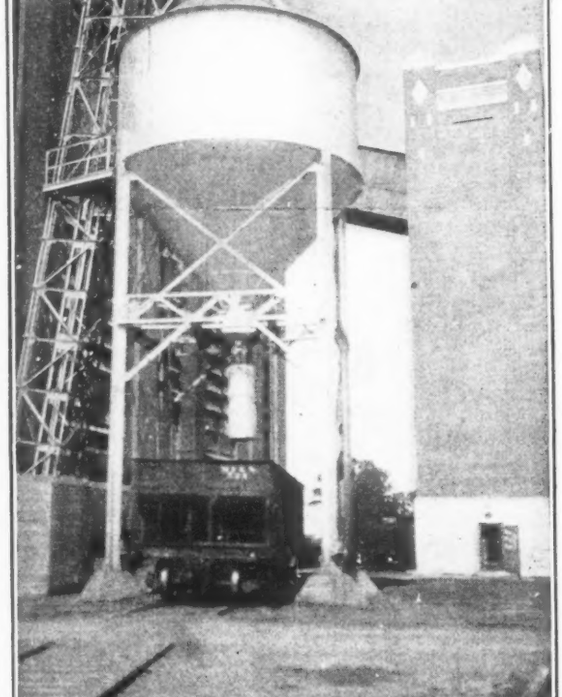


Fig 6—Ash hopper and elevators

It was found that considerable dust escaped from the mill-cyclone vent, so the vent was closed and a connection made between the mill fan discharge and the suction of the drier fan. The entire mill circuit is now operated under a slight suction. This applies to the four units.

The drier cyclones discharge the entrained lignite dust upon the main screw conveyor, and it was found that with a pressure within the cyclone, air got through the conveyor into the pulverized-fuel bins. As this air was hot and practically saturated with moisture, upon cooling in the bins, moisture was deposited on the sides. This resulted in the formation of a muck which clogged the feeders. Alterations to the cyclones to produce a suction in the base of each drier cyclone has eliminated this trouble. The drier cyclones vent into steam and water jet air washers.

Occasionally, a crust forms over the lignite in the bins, but this has presented no serious difficulty.

Clogging of feeder screws is the main operating problem, although the stoppage is immediately eliminated by removing hand plates and using a rod. As the capacity of a boiler depends on the screw capacity, it is necessary that the screw delivers its full rating at the driving speed. It was found that even a $\frac{1}{8}$-in wear in the blade diameter reduced the capacity more than 50 per cent. New screws of a larger capacity with helixes built up with stellite have been installed.

These feeders are driven in gangs of six by Reeves variable-speed transmission. The operator on the boiler firing floor controls the feeder speed through distant control of the Reeves drive setting. The control is at the side of each boiler, as shown in Fig. 5. When the plant was started, some trouble was experienced with breaking of the transmission belt. This was caused by running the belt at maximum speed in order to handle sufficient fuel. With larger-capacity feeder screws the trouble has disappeared.

From the very start no trouble has been experienced with the actual burning of the pulverized lignite. When a fire is to be lighted a torch is inserted below the nozzle, and as soon as the lignite starts flowing ignition takes place quite as if gas was the fuel. Originally, the nozzle tips protruded into the furnace beyond the refractory lining; some melting took place, and as a consequence the nozzle was shortened.

The flame shoots downward and follows the form of the letter U in going into the passes of the cross-drum boilers. By regulating the primary air the flame can be made almost to strike the furnace floor before starting its ascent. Too little air permits the flame path to be shallow, the flame continuing to burn after it enters the boiler passes.

Excellent Furnace Results Obtained

After a little experience the operators have been able to obtain excellent furnace results; the CO_2 ranges close to 15 per cent. Of the ash not over one per cent is combustible, and so little ash is carried out of the stacks that very little color appears at the tops.

The ashpits have a slope of 30 deg., but it has been found that the ash will not slide down to the ash conveyor. Air jets are now being used.

The boilers have given no trouble, nor have the water-wall tubes. The feed water makeup is taken from an artificial lake supplied from Trinity River. River water gives analyses varying with the height of the river, but there is always a high sodium-carbonate content and a low sodium-sulphate percentage. It has been decided that the ratio of the sulphate to the carbonate should be about 3 to 1, while the actual ratio is about 0.3 to 1. To obtain a desirable ratio, sodium sulphate is added to the boiler feed to keep ratios in boiler water 3 to 1.

In order to eliminate the blowing down of a boiler when the alkaline concentration comes too high, a bypass is connected to all the boilers so that the highly concentrated water can be passed to the other boilers in case their contents are less alkaline. This is done by bleeding the high alkaline boiler into the boiler feed tank from which the alkaline is distributed to all boilers in the feed water.

About 1,000 tons of lignite is used per day, and to guard against shortage an outside storage pile of 17,000 tons is held in reserve.

Little difficulty is experienced with fires caused by spontaneous combustion in this storage pile. However, this freedom from fire is due primarily to the method of storage. The lignite is crushed before going to storage, and as freshly crushed lignite is added to the pile, it is spread in two-foot layers by a drag scraper. Each layer is then firmly packed by a roller drawn by a small tractor so as to prevent circulation of air in the pile. To prevent further the circulation of air in the pile, earth dikes were built on the sides of the pile facing the prevailing winds. Internal fires due to spontaneous combustion occurred occasionally along the windward sides of the pile before the dike was built and also where the lignite was not closely packed. However, internal combustion is now very rare except where the surface has been broken by lignite removal.

Regardless of the length of storage the lignite contains about the same amount of water as when received. The only water lost is apparently the surface moisture, and although the lignite may air-slack into small particles, the entrained moisture shows little shrinkage.

What Do You Know?

By L. H. Morrison

The answers are on page 440

Ques. 1—Suppose it was necessary to maintain the engine speed constant and the shaft governor weights could not be changed. What would be necessary if the steam going to an engine was raised from 75 lb. to 125 lb., if the speed is to be the same as before at a given load?

Ques. 2—What is an average value for maintenance of Diesel engine?

Ques. 3—If you had a tackle having a two- and a three-sheave block and it was necessary to move a heavy weight horizontally, would you attach the weight to the two-sheave or to the three-sheave block?

Ques. 4—A spring scale registers 25 lb. when a weight is hung on it. Will the scale reading change if the weighing is done on an elevator moving up at an acceleration of 10 ft. per sec. per sec.?

Ques. 5—A submarine weighs 1,000 tons and displaces, when submerged, 2,000 tons of water. Suppose this fills with water and sinks in 200 ft. of water and becomes buried in sand to its widest horizontal plane, what would be the force necessary to raise it if the area of the greatest plane is 2,500 sq.ft.?

Ques. 6—If the stator of an eight-pole wound rotor induction motor is connected to a 60-cycle circuit and the rotor is driven backward at a speed of 1,800 r.p.m., what will be the frequency of the rotor current?

Ques. 7—The plunger of a steam boiler feed pump makes short jumps when beginning its stroke. What is the reason?

Ques. 8—What is the "factor of evaporation"?

Ques. 9—Who built the first producer gas engine?

Ques. 10—What is humidity and how is it determined?

Design and Application of
Forced Draft Chain Grates

By T. A. MARSH
Western Engineer, Combustion Engineering Corporation

FORCED-DRAFT traveling grates are well suited to the burning of the following fuels: Anthracite; coke breeze; bituminous coal (free burning); subbituminous coal; lignite. For anthracite and coke breeze this type of stoker is almost alone in the field. For the other three fuels other types of stokers are adaptable. Bituminous coal with a percentage of ash below 10 and a fusion point of ash above 2,200 deg. F. is excellent coal for underfeed stokers. If the ash content exceeds 10 per cent and the fusion temperature is below 2,200 deg. F., traveling grates have points of advantage.

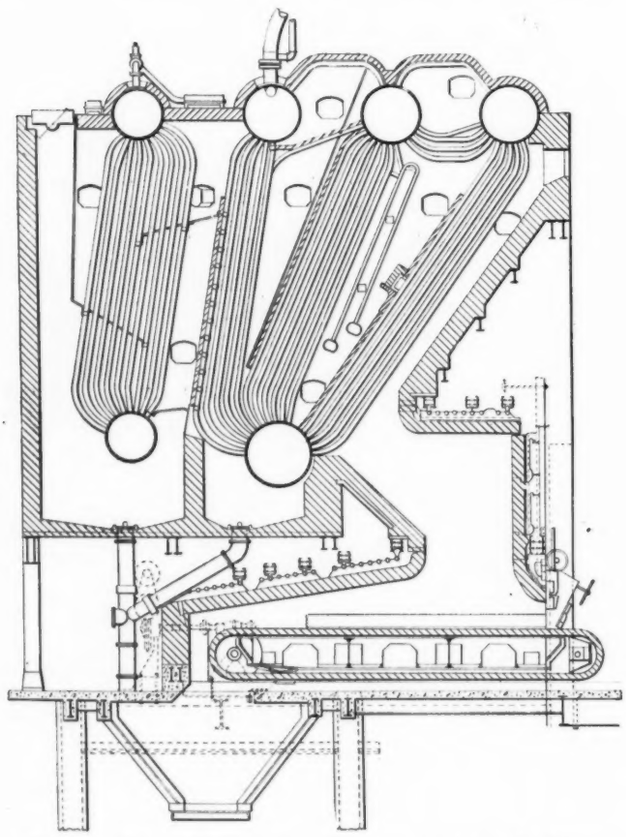


Fig. 1—Forced-draft traveling grate with coke breeze or anthracite furnace

Coals for traveling grates should be free-burning and non-coking. However, the range of fuels adaptable to forced-draft traveling grates from a coking and caking point of view is wider than is the case with natural-draft chain grates. This is due to the "boiling" or stirring action of the forced draft on the fuel bed.

Numerous attempts were made to apply forced draft to natural-draft traveling grates, but without success. Usually, the attempt was simply to inclose the stoker and then apply a uniform pressure to the entire grate surface. This resulted in holes in the fuel bed and the admission of large quantities of excess air into the furnace.

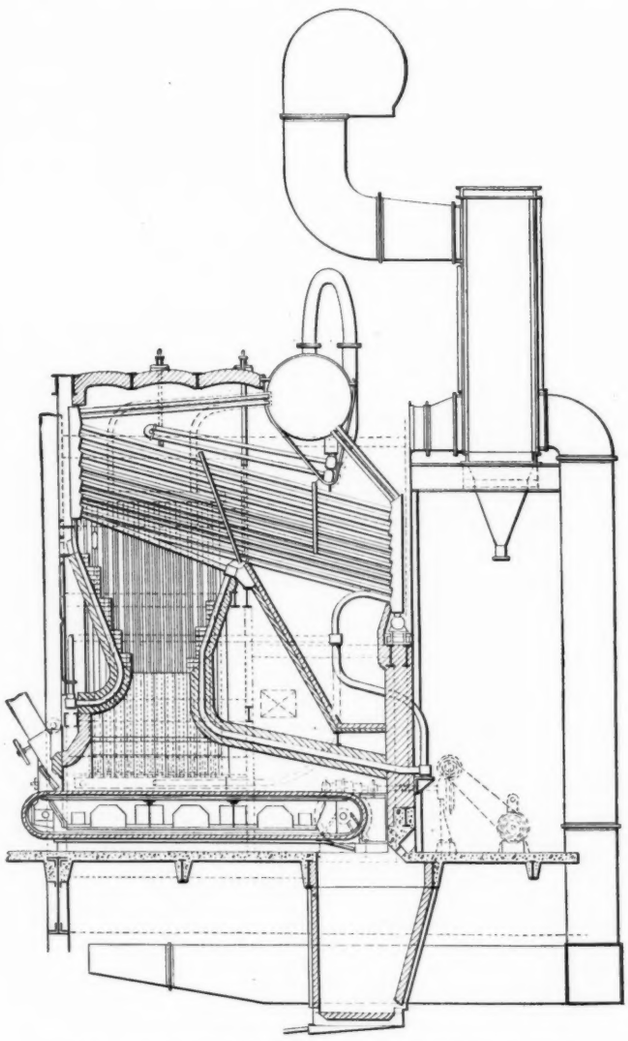


Fig. 2—Forced-draft traveling grate with coke or anthracite furnace of another type

It was thus made evident that the application of forced draft to the traveling grate must be accomplished by means of the zone or compartment system in which the

pressure can be regulated for different parts of the grate surface. The earliest successful stokers of this type were designed and built by Eckley B. Coxe for the burning of small sizes of anthracite. They proved satisfactory and the application is still the proper one. It proved to be possible to burn anthracite culm and washery waste on these stokers, as well as commercial sizes. Small-sized waste anthracite recovered from river beds by dredging has also proved to be a good fuel for these grates.

Success with anthracite led to the attempt to utilize coke breeze, which also proved successful. Following this, the attempt was made to use high-ash bituminous coals. The standard stoker, at the time, for this latter fuel was the natural-draft chain grate, which gave good results at ratings up to 200 per cent. Higher ratings were sought, however, and it was most logical to use the established form of stoker with the addition of forced draft with compartments.

Forced-draft traveling grates are made with two general designs of grate surface—carrier-bar grates and link-type grates. Carrier-bar grates were developed for anthracite and coke breeze. With this type stoker the grate surface consists of continuous bars the width of the stoker, which engage separate keys forming the surface. Individual keys are removable, also entire sections the width of the stoker.

As the number of installations of forced-draft traveling grates increased in the bituminous fuel field, it became evident that the low fusion temperature and fluxing action of some ashes imposed a maintenance condition on carrier bar stokers more severe than with anthracite and coke breeze. This led to the development of a forced-draft chain grate for bituminous coals with links assembled on rods in staggered formation, similar in construction to the design used for natural-draft chain grates. The chief differences between natural-draft grate elements or links and forced-draft chain-grate links is that the latter are made heavier, to afford a mass of metal to conduct heat from the surface. A second difference is that the percentage of air space in forced-draft chain-grate surfaces is from 6 to 8 per cent, or about one-third of that used in natural draft practice. The compartment or zone arrangements of forced-draft traveling grates also fall into two general classifications—those in which the bottom of the compartment or air seal is below the lower strand of grate, and those in which the compartments are entirely between the upper and lower strands of grate. In the former the siftings dropping from the fuel bed are carried through the lower strand. With compartments sealing below the lower strand of chain in cases where preheated air is used for combustion, the lower strand of grate is at all times in the heated zone with no interval of cooling. It is evident from operating installations that a higher degree of preheat can be safely used with stokers having the compartments between the grates. Temperature differences of grates as high as 125 deg. F. have been noted between these two designs. When compartments are between strands of grate, there is practically no blowing out of dust into the boiler room. This is due to tighter compartments and to the fact that no siftings are caught in the lower strand of chain to blow out at the front.

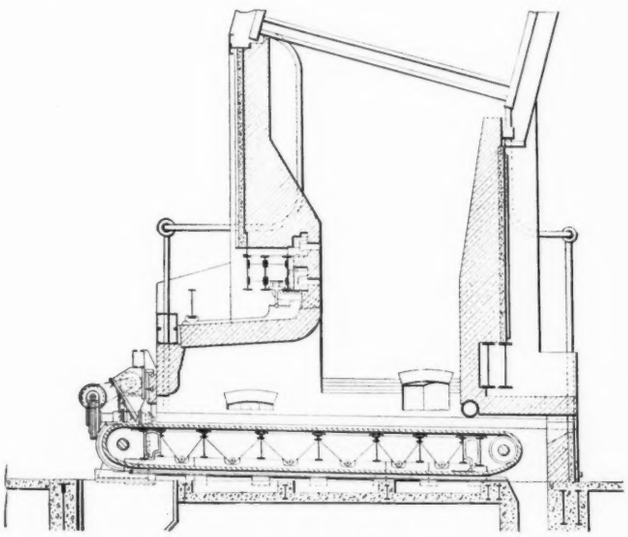


***Fig. 3**—Forced-draft traveling grate with bituminous coal furnace*

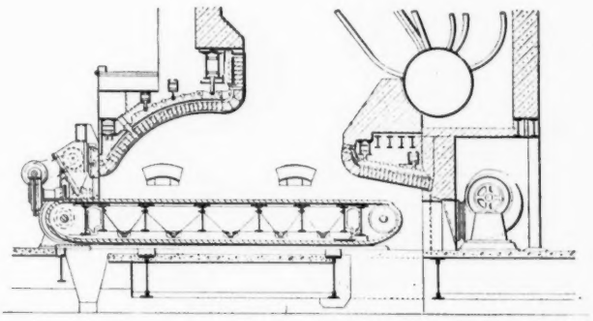


Fig. 4—Another type of bituminous coal furnace with forced draft traveling grate

Provision must be made for the removal of siftings from the compartments when internal compartments are used. Various mechanical conveyors have been used. These are at a disadvantage due to inaccessibility and wear. The use of steam or air jets in series is a simple and practical method of removing siftings with no moving parts to wear or break.

Stokers up to about 12 ft. wide can be supplied with air from one side successfully. Wider stokers usually have air requirements too high to be supplied from one side without exceeding critical velocities. In such cases not only is there a pressure drop due to friction losses, but the air introduced below the grate at unduly high velocities builds up a pressure on the side opposite the entrance and tends to burn fuel more rapidly on the high-pressure side of the grate. This effect is particularly noticeable if the air space in the grate exceeds 7 or 8 per cent. The grate surface then has such slight resistance to air flow that there is nothing to equalize the pressure of air from side to side of the stokers. This is one of the chief reasons for the low percentage of air space used.

The increase in the size of boiler units and steaming rates calls for stokers of this type of large size. The Crawford Avenue Station of the Commonwealth Edison Company has stokers 24 ft. wide by 20 ft. long. Sizes

in excess of this are known to be possible and practical. The larger sizes of stokers were originally driven by motors on each side. The great difficulty, however, of obtaining uniform operation of the two motors led to a change to single drive with motor and driving gear on one side only.

Furnaces for Forced-Draft Chain Grates

Furnace designs for forced-draft stokers differ from those of natural-draft stokers in that not as much arch is required for ignition of a given amount of coal. Arches must be set higher, however, to avoid the erosive effects of the draft. Some typical furnaces for anthracite and coke breeze are shown in Figs. 1 and 2. It will be noted that the arch effect is quite pronounced. There is also a rear or reversed arch and a relatively narrow furnace outlet. In some cases the rear arch has been made longer than the front one, causing the products of combustion to pass counterflow to the fuel bed. This is an excellent method of improving ignition, as it adds convection effects and improves radiant effects. In anthracite and coke breeze furnaces rear arches can be maintained without protecting waterbacks. Side walls above the grate line can be maintained with air-cooled or carborundum blocks. The problem is one of building up high furnace temperatures.

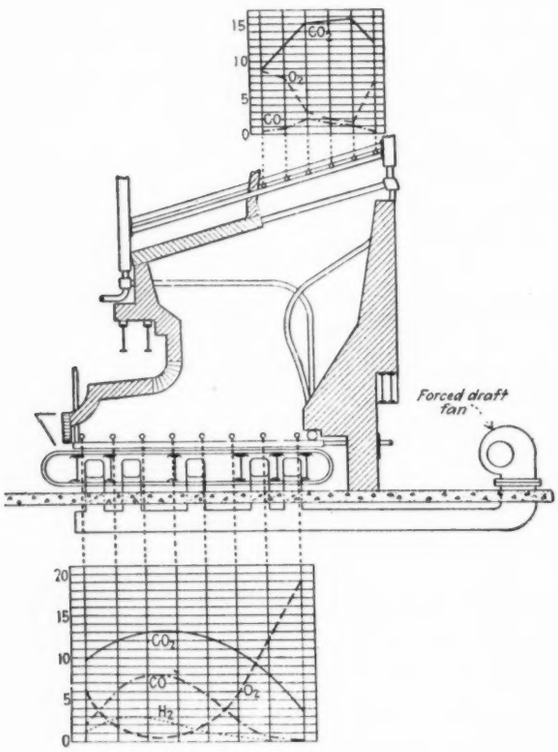


Fig. 5—Results of furnace and first-pass exploration on typical forced-draft chain grate installation

Many bituminous coals have an excess of lime and other fluxes that are severely detrimental to brickwork. Furnaces ideal for anthracite and coke breeze would be not only unsuitable for bituminous coal but impractical from a maintenance standpoint. Figs. 3 and 4 show typical furnaces for bituminous coals. It will be noted that rear arches are little more than bridge-wall overhangs. Waterbacks are most desirable protecting the front of the rear arch or the face of the bridge wall. Side waterboxes along the grate line are almost a necessity, as carborundum does not perform well with high-ash coals having severe fluxes.

The higher rates of combustion with bituminous coal, however, produce furnace conditions that introduce new problems. A less amount of excess air is needed. Combustion rates are increased up to as high as 55 lb. One of the difficulties encountered was an excess amount of smoke. This was true even when furnace volumes were liberal.

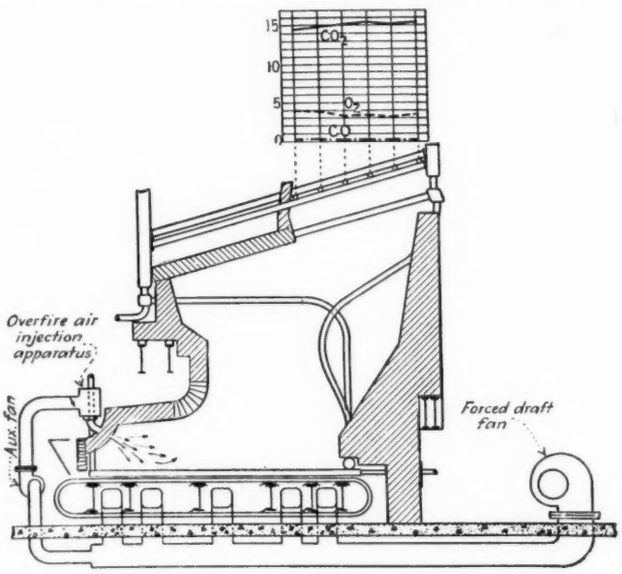


Fig. 6—Furnace equipped for distribution of overfire air, the first-pass chart indicating improved results

The cause was investigated by means of gas samples taken at various points in the furnace and through the boiler setting. From these samples it was found that there was a marked deficiency of oxygen in the front of the furnace under the arch and a liberal excess at the rear near the bridge wall. The gases were stratified, through the furnace and the passages of the boiler, without proper mixture. Lowered combustion efficiency and smoke resulted.

Fig. 5 shows a typical set of results of furnace and first-pass gas exploration under these conditions. The deficiency of oxygen at the front of the furnace is very marked. This led to the application of overfire air at the front of the furnace. A system was developed by A. D. Bailey and A. E. Grunert of the Commonwealth Edison Company, using an auxiliary fan to draw air from the main windbox of the stoker and deliver it through venturi nozzles in the stoker arch. This system is shown in Fig. 6, which also shows the gas distribution found in the furnace and at the entrance to the boiler tubes when a proper amount of oxygen is supplied at the front. The uniformly high CO_2 is very marked in contrast to the results obtained without this overfire air.

With the application of overfire air smoke was eliminated. The length of the flame was shortened, and the slag and soot deposits in the first pass of the boiler were greatly reduced. The improvement in the per-

centage of CO_2 and the elimination of some hydrocarbon losses caused a noticeable improvement to the efficiency of the boiler. Overfire air applied by means of a fan is now recognized as best practice for modern chain-grate installations. It is essential if best economy is desired and if smokelessness is a factor.

Operation with forced-draft chain grates is not as simple as with natural-draft chain grates because the pressures must be watched and controlled. However, operation is not difficult, for when the relative compartment pressures have been once established for any given fuel, little adjustment of these pressures is necessary. The whole range can be increased or decreased by varying the fan speed or main air duct pressure. Also, because of the continuous, uninterrupted method of operation, adjustments, once made, can be maintained within a close range for long intervals.

Results obtainable from this type of stoker are shown in the tables. Table I shows results from anthracite and coke breeze. Table II shows results from Illinois bituminous coals. Overfire air was used on these tests.

Forced-draft chain grates will burn any coal except the coking varieties. Low-ash coals, 7 per cent and below, are not desirable, as there is not enough ash to insulate the grate surface and protect it from the radiation of arches and side walls. High-ash coals, up to

TABLE I—TEST RESULTS WITH ANTHRACITE AND COKE BREEZE

	Type of Boiler	
	Edge Moor	B. & W.
1 Number of boilers tested	1	1
2 Duration of trial, hours	240	4
3 Total heating surface, sq.ft.	10,000	7,680
4 Kind of stoker	Coxe	Coxe
5 Width of grate, ft.	8'8½"	6'8½"
6 Length of grate, ft.	15'0"	13'0"
7 Area of grate, sq.ft.	262	175
8 Ratio, 3 to 7	39.8:1	43.9:1
9 Steam pressure, lb. gage	102.8	184.7
10 Draft in flue behind boiler, in.	.39	.5
11 Draft in furnace, in.	.08	....
12 Blast in compartment 1, in.	1.72	1.74
13 Blast in compartment 2, in.	1.18	1.34
14 Blast in compartment 3, in.	.81	1.06
15 Blast in compartment 4, in.	.17	.44
16 Feed water entering boiler, deg. F.	59.9	188.6
17 Escaping gas, deg. F.	560	545
18 Kind of fuel	Anthracite	Coke Breeze
19 Moisture, per cent	10.83	12.21
20 Volatile matter, per cent	7.69	4.63
21 Fixed carbon, per cent	77.86	78.58
22 Ash, per cent	14.49	16.80
23 Sulphur, per cent	.8	.97
24 B.t.u. by analysis per lb. dry fuel	12,534	11,750
25 Total fuel consumed, lb.	2,049,181	28,140
26 Dry fuel consumed, lb.	1,826,929	24,704
27 Total refuse, lb.	.....	5,673
28 Percentage of refuse	.....	22.96
29 Quality of steam	.9966	1.035
30 Factor of evaporation	1.1936	1.073
31 Water apparently evaporated, lb.	14,360,562	187,381
32 Water actually evaporated, lb.	14,311,736	193,939
33 Equiv. water evap., lb.	17,140,767	213,319
34 Equiv. water evap., per hr., lb.	71,420	53,330
35 Total heat per lb. of dry fuel	9,104	8,379.9
36 Efficiency, per cent	72.64	71.32
37 Water evap. per lb. of dry fuel, actual lb.	7.824	7.585
38 Equiv. water evap. per lb. of dry fuel., lb.	9.382	8.635
39 Water evap. from and at 212 deg. F. (heating surface), lb.	7.142	6.94
40 Per hour, per sq.ft. of grate surface, lb.	272.6	304.7
41 Dry fuel burned per sq.ft. grate surface per hr., lb.	29.05	35.29
42 Grate travel per hour, ft.	19.6	....
43 Thickness of fire, in.	5.23	....
44 Lb. of dry fuel per hour per hp. developed	3.68	4.10
45 Per cent rating developed	207.01	201.2

40 per cent of ash, are entirely suitable. Bituminous coals with from 10 to 25 per cent of ash are ideal. With such coals combustion rates up to 50 lb. of coal per square foot of grate surface per hour can be obtained readily, and occasionally peaks of 60 lb. have been obtained.

This type of stoker is established in central station practice for high-ash bituminous coals. It has also been adopted widely by large industrial plants desiring ratings of 200 per cent or more from the boilers.

At present the competition between stokers and pulverized coal is close. It would be idle to predict the outcome. At the present writing some installations analyze favorably for pulverized fuel and others are definitely stoker plants. With its adaptability to low-grade

TABLE II—FORCED-DRAFT CHAIN-GRATE STOKER TESTS
Using Illinois coal with overfire air injection

Test no.	14	13	3	4	2
Duration, hours	7	7	6.5	5	7
Rating developed by boiler, per cent	165	193	201	222	224
Coal as fired					
Moisture, per cent	18.40	16.48	17.26	17.12	16.56
Ash, per cent	12.72	13.30	11.72	12.13	13.40
B.t.u. per lb.	9,745	8,931	10,042	9,988	9,676
Fired per hour, lb.	9,964	11,591	12,407	14,012	13,956
Actual evap. per hour, lb.	71,782	84,380	86,600	95,710	96,077
Actual evap. per lb. of coal, lb.	7.20	7.28	6.98	6.83	6.88
Temperatures, deg. F.					
Air to preheater	109	114	91	90	87.5
Air leaving preheater	179	181	165	173	187
Air entering furnace	179	181	165	173	187
Gases leaving boiler	572	610	570	596	608
Gases leaving economizer	272	291	255	285	313
Gases leaving preheater	218	220	189	203	249
Feedwater to economizer	159	161	150	155	159
Feedwater to boiler	282	283	255	260	257
Superheated steam	676	674	683	686	694
Pressure, lb. per sq.in. abs.	578	576	569	570	543
Pressure air injection, in. of water	0.01	0.05	0.22	0.26	0.73
Drafts, in. of water					
Ignition	0.11	0.126	0.08	0.09	0.12
Boiler exit	0.69	0.86	0.39	0.50	0.60
Economizer exit	1.32	1.69	1.08	1.36	1.70
Preheater exit	2.00	2.50	1.34	1.66	2.47
CO_2 boiler exit, per cent	12.3	12.8	11.9	13.9	12.9
CO_2 economizer exit, per cent	10.2	10.8	11.35	12.9	12.1
CO_2 preheater exit, per cent	10.0	9.8	11.11	11.4	10.65
O_2 preheater exit, per cent	9.5	9.3	8.32	7.8	8.72
CO preheater exit, per cent	.....	.....	.....	.....	.....
Heat balance, per cent					
Absorbed by boiler and superheater	80.1	79.3	77.8	77.1	78.18
Absorbed by economizer	9.2	9.1	6.9	6.5	7.05
Total heat absorbed	89.3	88.4	84.7	83.6	85.23
Loss in dry flue gases	3.35	3.28	2.65	2.97	4.70
Loss due to moisture in coal	2.04	1.78	1.86	1.88	1.86
Loss due to H_2 in coal	3.79	3.76	3.80	3.81	3.92
Loss due to carbon in refuse	0.32	1.56	2.18	2.21	0.31
Loss due to carbon in CO	.....	.....	.....	.....	.....
Unaccounted for losses	1.20	1.22	4.81	5.53	.9

fuels, high ratings, ease of operation, efficiency and responsiveness, it is evident that the forced-draft traveling-grate stoker will hold a strong position in both the central station and industrial fields for many years.

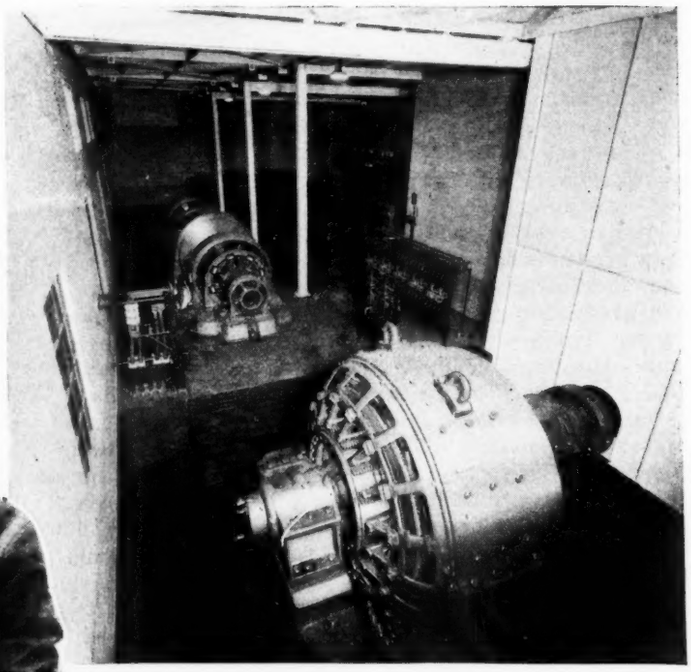
An Oil-Steam Engine for Locomotives

A NOVEL type of combined steam and Diesel engine has been proposed by R. Hildebrand, chief engineer, Diesel Department, Fulton Iron Works Co., for use on locomotives, to secure the superior economy of the Diesel engine without sacrificing the overload capacity of the steam engine.

It will be a double-acting machine operating on the two-stroke Diesel cycle and the locomotive will be equipped with a high-pressure boiler. The locomotive will be started as a uniflow steam engine, and when the train is moving at a speed of, say, 4 miles per hour, steam will be shut off and fuel will be introduced for operation as a double-acting Diesel. When heavy grades or high speeds require power beyond the efficient capacity of the Diesel cycle, a special valve gear permits the admission of steam to the cylinder after the combustion of the oil fuel has been completed and after the products of combustion have expanded to a pressure just below the steam boiler pressure. As the steam is admitted into a cylinder so hot that no condensation occurs, a fair steam economy is expected.

The Diesel-Hildebrand engine differs from the Still engine, in that the Still engine utilizes steam in one end of the cylinder, and the Diesel cycle in the other end.

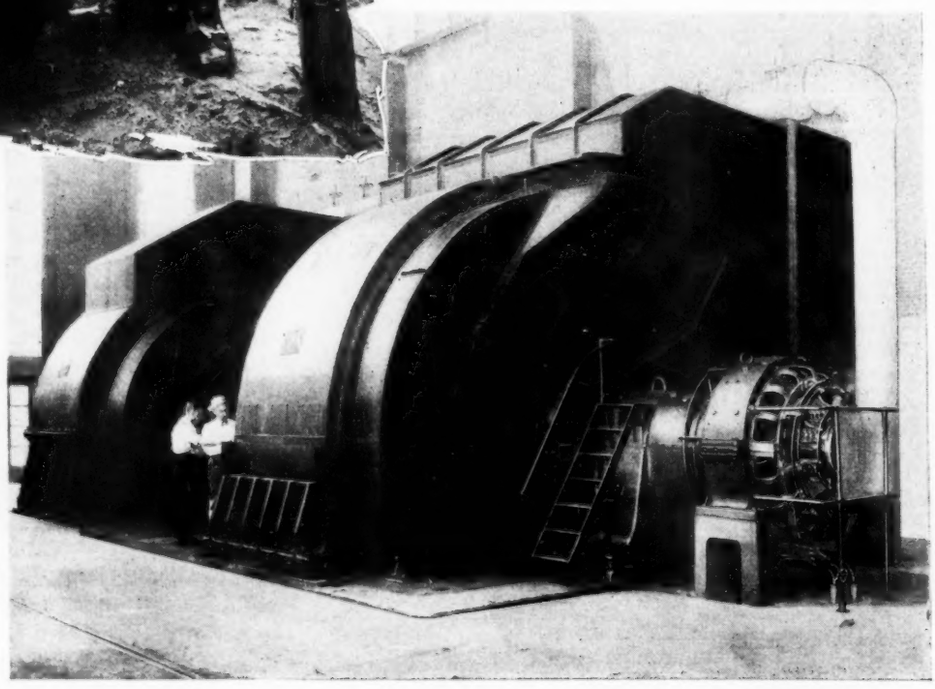
At the Ends *of the* Power Plant



Above—A 2,150-hp. direct-current General Electric motor, which operates at a speed of 43 to 86 r.p.m. and drives a 28-in. reversing mill in the plant of the Standard Seamless Tube Company, Economy, Pa. This is the first motor of this type supplied from a synchronous-motor generator set

Below—A 40,000-kva. 25- to 60-cycle Westinghouse frequency changer on the power system of the Commonwealth Edison Company, Chicago

Above—Boulder removed from one of the caissons for the addition to the Charles R. Huntley Station of the Buffalo, Niagara & Eastern Power Corporation. Diver M. J. O'Neil, seen at the right, made the connection to the boulder, which was down about 40 ft. in muddy water. The work was done in absolute darkness, and several attempts were made before the boulder was finally removed



Developments in European Steam Turbine Design

By C. H. S. Tupholme

GREAT efforts have been made in recent years by European steam turbine designers to reduce the heat consumption of these machines on account of the rise in the price of coal following the War and because of the enormous increase in the capacity of these units.

The means of attaining the object in question are to be sought, first in the improvement of the efficiency of the turbine itself; secondly, in the increase of the heat

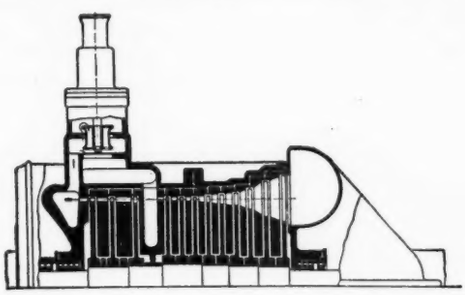


Fig. 1—Old method of introducing steam to high pressure stages

drop available for the turbine by raising the steam pressure and temperature; thirdly, in the improvement of the heat process by regenerative arrangements and intermediate re-heating of the steam.

It may be of interest to mention that the Oerlikon Company, one of the leading manufacturers of turbines in Europe, to whom the writer is indebted for the following details, obtained efficiencies of 75 per cent and more with their turbines as far back as 1913; since then the efficiencies have been improved and reach, at the present day, values above 80 per cent.

The latest design of these turbines includes an impulse type with, as a rule, partial admission in the high-pressure part, and full admission in the low-pressure portion. The number of stages varies with the heat drop and speed. At the present day, the number of stages at 3,000 r.p.m. has been increased from 10 and 13 to 12 and 16, the diameter of the high-pressure part being considerably smaller than that of the low-pressure section, in the case of large units. When the steam pressure exceeds a certain value, about 355 lb. per sq.in., the turbines are built with the casing in two sections, from average capacities upward. The runners of the high-pressure part are then designed with a smaller diameter, and the corresponding casing is made of special cast steel.

In the case of high capacities, 12,000 kw. and more, where the large quantities of steam in question cannot be used efficiently in one stage, owing to the high vacuum, the stream of steam is divided into two or three parts. This has led to the construction of two- and three-flow turbines which are provided with a casing in two or three sections according to the initial pressure. In view of this turbines are being constructed up to 40,000 kw. at 3,000 r.p.m. and 150,000 kw. units at 1,500 r.p.m. with high efficiencies.

The firm referred to has always used pressure stages only, even in the high-pressure part, in the case of units for large and average outputs, having dispensed with a velocity stage wheel. The advantage of velocity stage wheels of permitting operation even at overloads, at the same high efficiency as at full load, is secured in this case through the adoption of a new method of admitting steam to the high-pressure stages.

Fig. 1 shows the old method of introducing steam and Fig. 2 the new arrangement. Formerly, the additional

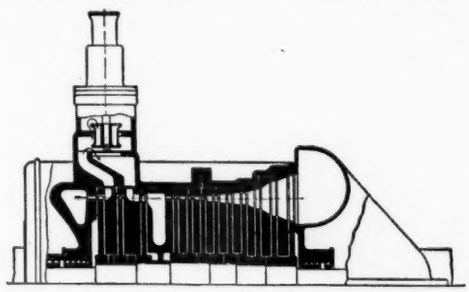


Fig. 2—New method of introducing steam to high pressure stages

steam was admitted after the high-pressure wheels, so that the steam did not produce any work in the high-pressure part. With the new design, however, the additional steam is also led into the first stage and, after flowing through it, passes into the third stage. Under normal conditions the channels in question are closed by valves, so that no additional steam is admitted. As soon as the turbine is overloaded or the normal quantity of steam is insufficient for developing the desired output, the auxiliary valves open and permit the passage of additional steam through the first and third stages, where it produces work. It may be pointed out that the heat drop in the high-pressure part is smaller during overload than during normal load, as the pressure in the intermediate chamber after the high-pressure wheels increases as a result of the larger volume of steam; consequently, the heat drop of high-pressure steam can be utilized advantageously in two stages.

These turbines are, as a rule, arranged with partial admission in the high-pressure part; the diaphragms are of wrought iron, and the guide blades are arranged in

two or four groups in boxes. In the part of the turbine with full admission the blades are cast into cast-iron diaphragms. Guide blades, as well as runner blades, are made of stainless steel, in order to prevent rusting.

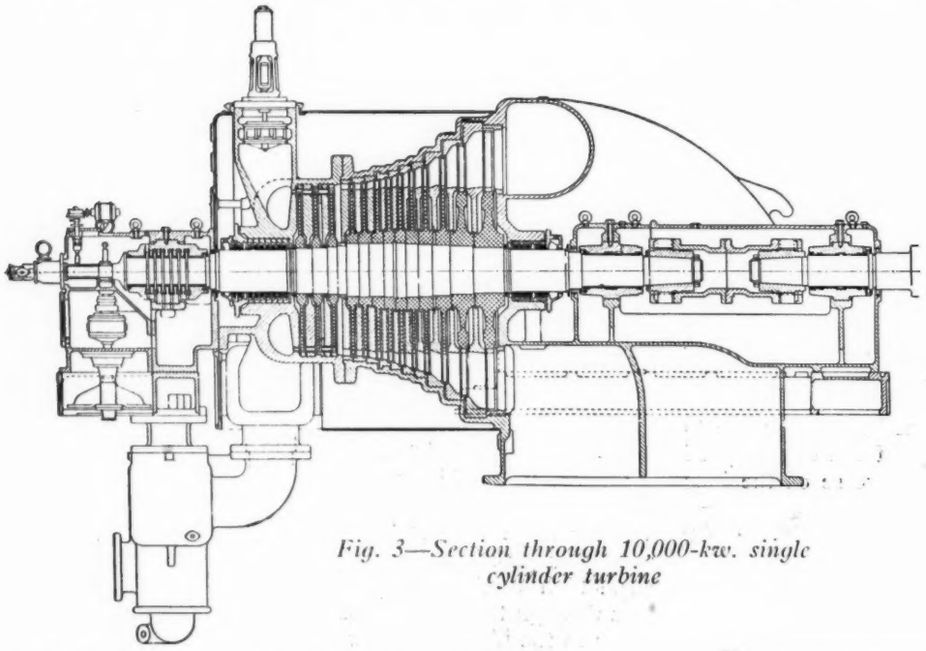


Fig. 3—Section through 10,000-kw. single cylinder turbine

Fig. 3 is a section through a 10,000-kw. turbine with casing in one piece; Fig. 4 is a section through a 30,000- to 40,000-kw. three-flow turbine, the speed being in every case 3,000 r.p.m. The steam flows first through the high-pressure part where the stages have a small diameter, and then passes into the medium-pressure portion. In the low-pressure part the steam flow is divided into three streams, which are led through different low-pressure sections. One of the low-pressure sections is arranged in the same casing as the medium-pressure part, while the other two are in a third casing. The turbine can be provided with one, two or three condensers.

Two steam inlets are provided, with two stop valves and two throttle valves; there are also two overload valves, the second overload valve alone being mounted on the high-pressure casing. The governor gear acts in such a way that, once the channels for normal steam supply are fully open, the second overload valve opens completely and the first overload valve throttles the steam supply through the additional channels to the first stage, until the full overload of the turbine is reached.

The output of the turbine is usually regulated up to normal load by throttling the steam. Tests on different machines have shown that the gain secured by cutting out individual nozzle boxes, at half load, amounted to only 1 to 2 per cent; consequently partial load valves are installed now only when the turbine has to operate for long periods at partial load.

The new method of admitting steam can also be used for improving the steam consumption at partial load. In this case the turbine is calculated for a smaller output, 80 per cent of normal load, for instance. Additional live steam is introduced through the steam channels that would otherwise be used only for overloads.

The table shows the acceptance tests of a 10,000-kw. turbine recently installed. As the turbine was to be used only at low loads (2,500 to 5,000 kw.) during the first years, it had to be arranged so that the plant could operate satisfactorily at partial load. For this purpose the turbine was designed so as to have its best steam consumption at 8,000 kw.

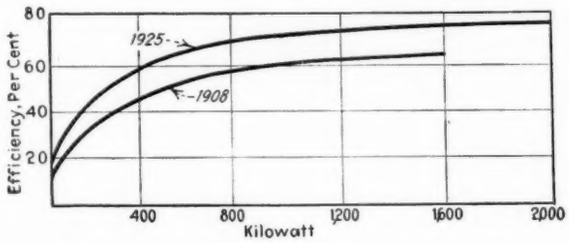


Fig. 5—Improvement in turbine efficiency

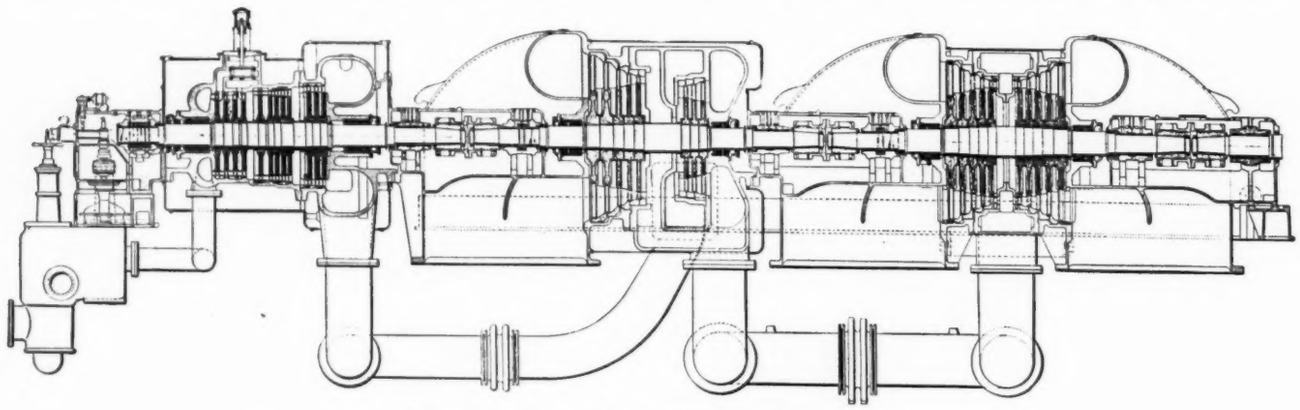


Fig. 4—Section through a three flow turbine

In Fig. 5 comparative curves are plotted showing the improvements in turbine efficiencies obtained during recent years. It shows the improvement in steam con-

sumption and efficiency obtained in the case of two turbines installed in 1925 at the Wood Lane power station of the Kensington and Notting Hill Electric Lighting

ACCEPTANCE TEST ON 10,000-KW. TURBINE

Load, in per cent	90	80	60	40	25
Steam pressure in lb. per sq.in. gage	185.8	211.1	201.7	205.4	203.6
Temp. in front of turbine, deg. F	657.1	662.0	642.7	647.6	631.9
Steam pressure at first diaphragm, lb. per sq.in. gage	183.1	181.9	142.8	95.2	61.0
Vacuum at outlet of turbine, in. Hg	28.09	29.20	29.34	29.36	29.49
Steam consumption per kw.-hr., lb	10.21	10.02	10.40	10.68	11.64
Output, kw	9,067	7,840	6,128	4,057	2,505
Efficiency of generator, per cent	95.0	94.8	93.5	91.4	89.1
Power factor	0.971	0.965	0.913	0.898	0.795
Efficiency of turbine	79.7	80.2	81.5	82.8	81.1

Companies to replace machines installed in 1908. The increase in the efficiency of the turbines amounts to about 25 per cent of the 1908 value.

Modernization vs. Executive Resistance—V

The Engineer Laughs Last

WHY, Bill, sit right down there—I haven't seen you long enough for a real talk for months and months, not since before we began to build our new power plant. You bet I've been pretty busy—I'll tell the world. Well, that's all over now and I can rest up a bit and look around to see who's coming. Yes, we got her all ready and started up three weeks ago and now she's settled down nicely, and say, she sure is delivering the goods. Boy, our coal is down 40 tons a day and we are making 20 per cent more product, with putting on an extra machine and speeding up the old ones. Steady dry steam all the time and plenty of power everywhere; that spells production, and the beauty of it all is the power don't cost us half what it did when operating the old plant.

Well, I certainly had a time of it while it lasted. The job of buying and building equipment for these new plants takes a lot of time and it can't be rushed, and we all made the mistake of expecting it to be finished about three months before it was humanly possible. You know the old man—he's a darn good sort and I ain't saying a word against him now, but patience is no virtue with him, and I had a hard time persuading him it was no use getting fires under the boilers before the steam piping was finished. Yeh, my piping was behind schedule, because it takes a long time to get these high-pressure valves, or at least it took us a long time.

That's one place we made a little mistake, I think, now we come to look back on it. Instead of letting the firm of engineers who were doing the main work for us take the whole job, lock, stock and barrel, the boss figured he'd save a bit if we did part of the job like the piping and electrical work ourselves, and so we fixed it that way. It was all right with our engineers, but we soon found it meant an awful lot of extra work on us owing to our not having much in the way of a drawing office and then having to do all of our consultations with their head office by mail.

It may have saved us a bit on the bills, but I ain't so sure even on that point, and anyway I figure it meant a month's delay in starting up the plant. So that's a point for you to remember, Bill, if you ever come to build a power plant, which maybe you won't, seeing you're a shoe salesman—sure, I daresay you do make more money; that wouldn't be very hard, though give me a real engineering job, money or no money.

But all that's got nothing to do with what I was telling you about our new plant and the boss being all het up with wanting to start before we could get ready. Of course it's been a pretty tough time keeping the old plant up to the mark without spending any more money on it than I could help.

I'd figured out when we first started to build the new plant that it was no use throwing a whole lot of money into repair on the old junk we were going to scrap, and so I saved all I could that way, doing just enough to keep things going all right till we were ready to start up the works. That went fine till we found we were going to be about three months behind schedule; then

"Our coal is down 40 tons a day and we are making 20 per cent more product"

the fun began, and I can tell you we had one lovely time. Oh, we got by all right but we took a lot of risks, and I hate to think what might have happened. What with extra work on the one hand with keeping the old plant going, and more extra work on the other with looking after the new stuff going in, it's a wonder if my hair ain't all turned gray.

The boss was pretty tough to handle those days; you know all that fool talk in the papers the last few months about how this good business couldn't last much longer and how we were due for a slump, with all kinds of fancy statistics to prove it. That got the old man's goat every time, and right away he'd come round with a stack of figures that proved that we could never do enough business to pay one per cent on the new investment, and he'd better send a case or two of Scotch to the receiver so's he'd get let down easy when his bankruptcy case came on, and what would his poor fatherless children do when he was gone and so on.

Well, that's all over now, and he's forgotten all about his doubts and orders are coming in better than ever. He's all pep and self-confidence now, and figures that as a real up-to-date pioneer of industry he don't have to take a back seat to nobody. That's all right; he certainly had the courage to risk his own money, and now he's due to draw the profits. And talking about profit, I ain't done too bad myself. Just take a glance out of the window—pretty nice automobile, eh? Yeh, traded in my old flivver last week, on the strength of my raise; so I guess after all our worries, I got the last laugh.

Darn good sort, old Bliman!

HEATING *and* VENTILATING

Heating World's Largest Office Building

By ADOLPH S. SYSKA, ENGINEER

Office of Clyde R. Place, Consulting Engineer

The heating system in the Graybar Building presents some interesting features because of its size and lack of basement space in the building.

Graybar Building, New York City

THE recently completed Graybar Building is situated between Forty-third and Forty-fourth Streets on the west side of Lexington Avenue, New York City. It is a thirty-one story building, noteworthy not only for size but also for many unusual features, and is one of the largest, if not the largest, office building in the world. It has a total volume of 16,000,000 cu.ft. and a total floor area of 1,250,000 sq.ft., above the street level.

The transportation facilities of the Graybar are unequaled. An imposing concourse 40 ft. wide, extending along the entire south side of the building from Lexington Avenue to the Grand Central Terminal, gives direct access to the trains of the New York Central and the New York, New Haven & Hartford Railroads. It also gives direct access to all the subway systems in New York City. By way of the building concourse Graybar tenants may travel to any point in the United States, may go to some of the finest hotels, banks, clubs and office buildings—all without ever stepping outdoors.

In the matter of vertical transportation the facilities are equally good. The building is served by 32 super-high-speed passenger and two service electric elevators. Twenty-four of these elevators are of the signal control type. They are practically entirely automatic, the operator's sole duty being to operate the door closing lever.

The entire building is built over space occupied by the New York Central Railroad tracks and workshops. The building and the railroad space underneath are separated by a horizontal plane that is only eighteen inches below the sidewalk. In other words, the lowest point of the Graybar Building is less than two feet below street grade at any point over its entire area Since this division plane is very strictly maintained, there is no basement to the building.

The absence of a basement will be immediately recognized by engineers as presenting a serious problem. Sanitary piping, electric feeders, telephone cables and heating mains usually are run in the basement. In the Graybar Building the basement had to be scattered to various spaces above grade. It may be said that in general, practically all mains were run on the mezzanine floor, which is immediately above the stores and shops that occupy the entire ground floor. Sanitary piping and

HEATING *and* VENTILATING

cold-water services from the street mains rise to the mezzanine floor along building columns as soon as they enter the building.

In some cases, such as in the case of incoming telephone feeders, it was imperative to carry the lines under the ground floor. The economic necessity for keeping the store floor as near as possible to grade, together with the restricted space available below grade, introduced further complications. An elaborate and ingenious network of structural steel had to be designed to provide the necessary space without encroachment on the railroad space below.

Some Features of Vacuum Heating System

The vacuum heating system embodies a number of interesting features. Steam is purchased from the railroad company. Uninterrupted service is insured by the fact that the service main connects to the railroad's two boiler plants at Forty-third Street and Fiftieth Street, as well as to the mains of the New York Steam Corporation. The steam enters the meter room at grade under a pressure of about 120 lb. Here the steam is metered by Bailey steam-flow meters and rises to the machinery room immediately above. At this point the main branches. One 8-in. high-pressure steam line rises to the seventeenth floor and a smaller line feeds a distributing manifold in the machine room. At this manifold the steam is reduced in pressure and supplied to hot-water heaters, store heating system and other special steam services.

The owners supply steam for all direct heating to all store tenants through the regular heating system. Steam for indirect heating and other purposes is delivered to each tenant through individual separately metered mains.

The 8-in. high-pressure line enters the reducing valve room at the seventeenth floor. Here the steam is reduced to 10 lb. in one stage and then further reduced to 2 lb. in the final stage. In this room are the hot-water heaters for the upper part of the building, and a separate high-pressure connection is made for this service, with separate reducing valves. All reducing valves are provided with relay switches which give a visual and audible alarm in the ground floor machinery room when the pressure exceeds a predetermined value. A diagram of the piping in the reducing room is shown in Fig. 1.

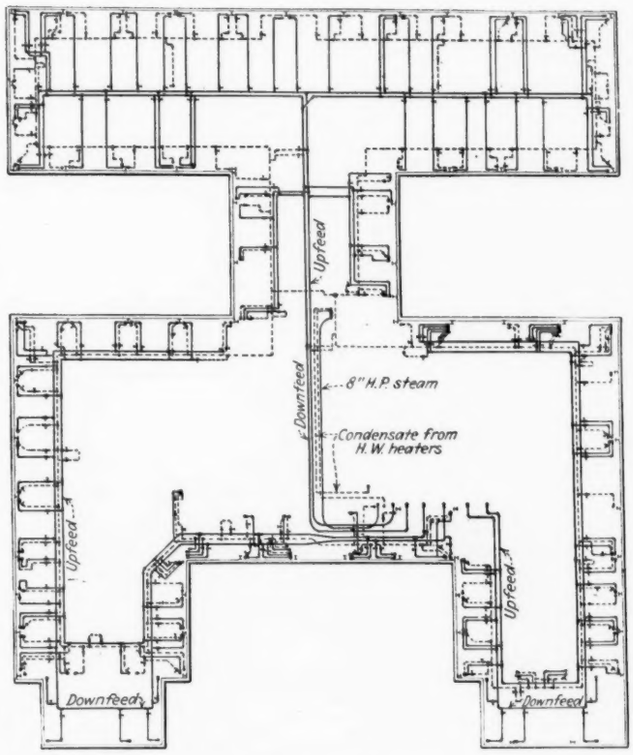


Fig. 2—Diagram showing heating system supply mains in pipe space above sixteenth floor ceiling

The low-pressure steam header is a 14-in. main, located near the ceiling. Connections are made to this main for feeding the various sections of the heating system. The building is divided into three sections—north, south and west. Each section has one up-feed and one down-feed heating main. This makes a total of six mains for the building, two 10-in. and four 8-in. These mains are all valved in the reducing-valve room, from which point the heating of all sections of the building is controlled. It is interesting to note that each section may be heated independently of the others, as outside temperature conditions may require. The control is entirely manual, all automatic fea-

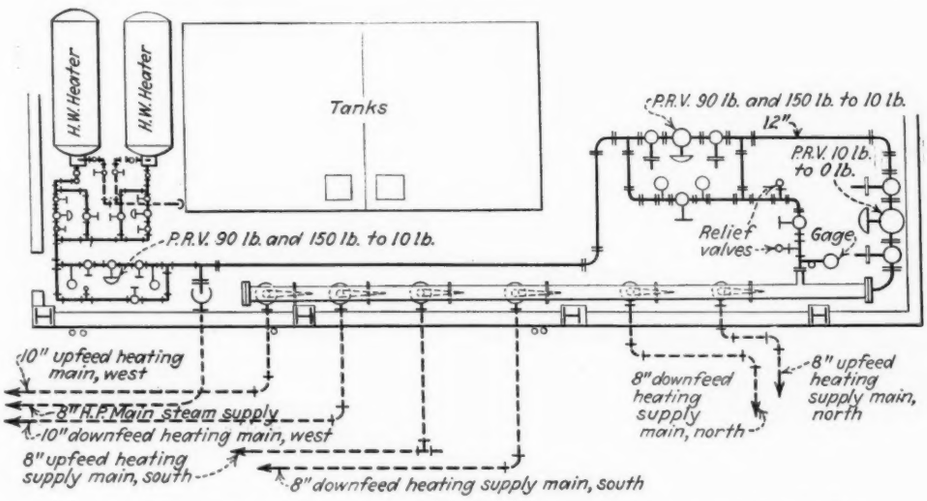

H.W. Heater
H.W. Heater
Tanks
P.R.V. 90 lb. and 150 lb. to 10 lb.
12"
P.R.V. 10 lb. to 0 lb.
Relief valves
Gage
P.R.V. 90 lb. and 150 lb. to 10 lb.
10" upfeed heating main, west
8" H.P. Main steam supply
10" downfeed heating main, west
8" upfeed heating supply main, south
8" downfeed heating supply main, south
8" downfeed heating supply main, north
8" upfeed heating supply main, north

Fig. 1—Diagram of piping in reducing valve room at the seventeenth floor

HEATING *and* VENTILATING

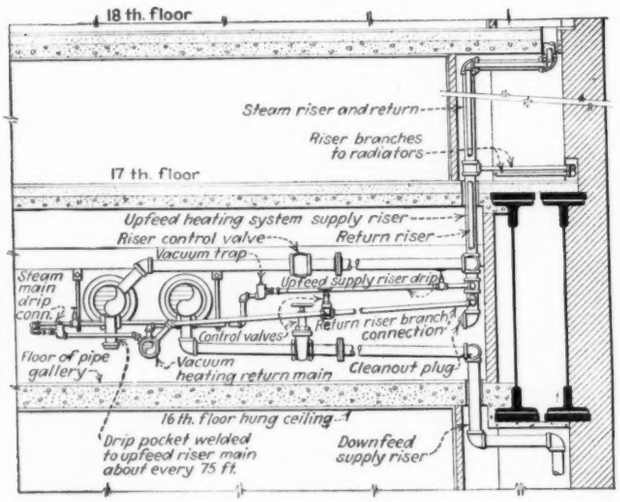


Fig. 3—Section through pipe space showing method of connecting risers to supply mains

tures having been carefully avoided wherever possible.

The six steam-supply mains distribute to the heating risers as may be seen in Fig. 2, and are located in a pipe space above the sixteenth floor ceiling. This floor was made five feet higher than the typical floor in order to provide convenient work space. Ventilation for the pipe space is provided by louvered openings at the end of each building bay. The mains are of standard-weight steel with welded joints and welded nozzles for riser branch connections. They are necessarily run with very little pitch. All up-feed supply risers are dripped at the base. The up-feed mains are dripped at intervals of 75 ft. through large reservoirs welded to the bottom of the mains. The down-feed mains are dripped through the riser branch connections which are taken from the bottom of the mains, as shown in Fig. 3.

The vacuum return main for the floors above the sixteenth is also located in the sixteenth floor pipe space. After collecting the returns from all risers, the main drops down the pipe shaft to the machine room, which is about ten feet above the street level. Here the up-feed vacuum return connects to a vacuum return header. This header is served by three Hytor vacuum pumps, each having a capacity of 100,000 sq.ft. of radiation. Two pumps can readily handle the maximum heating load.

The discharge from the vacuum pumps passes through two heat exchangers, or economizers, that preheat the water delivered to the hot-water heaters. The cooled condensate is then pumped to the plumbing waste line. Provision is being made to pump this water back to the railroad boiler plants below.

The vacuum returns from the down-feed heating system, comprising the lower sixteen floors, are collected by a return main on the mezzanine floor. This main is connected to the vacuum pump header in the machinery room.

The heating main for the mezzanine floor and the stores is also on the mezzanine floor. It is impracticable to get the returns from the store radiators back to the vacuum pumps, consequently these returns are collected in a shallow trench along the front of the building, are precooled and wasted to the sewer.

The modern skyscraper with its setbacks and extreme height, make it economically impracticable to distribute low-pressure heating steam to the top of the building from mains in the basement. The risers of necessity would become excessively large and cumbersome, complicating the design of the structural steel and increasing the difficulty of providing for proper expansion of the piping. The economical solution is to supply high-pressure steam to an intermediate floor, at which point the pressure is reduced and the steam distributed up and down to the heating system. The manifold merits of this system have been universally recognized, and it has

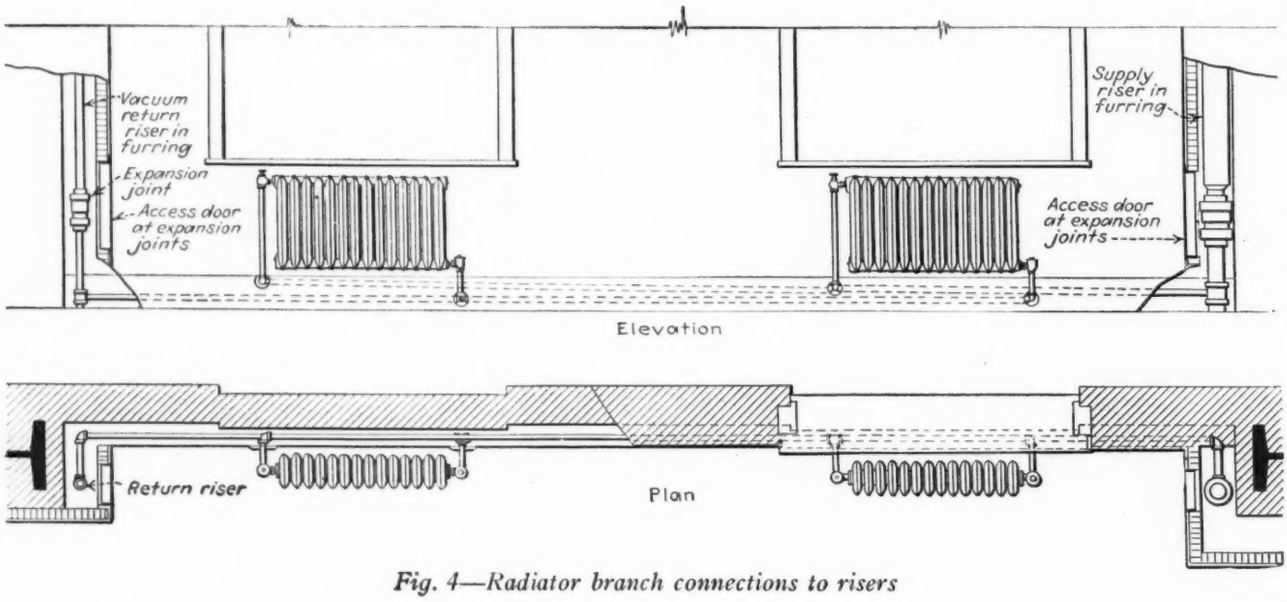


Fig. 4—Radiator branch connections to risers

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become practically the standard method for heating buildings of this character.

The Machinery Room

The machinery room of the Graybar Building is an interesting example of the modern engineering development in the present-day high-grade skyscraper office building, where space is always at a premium. The mechanical nerve center of this enormous building occupies a floor space of only 1,200 sq.ft. and has a total volume of only 24,000 cu.ft. In this restricted space are the house pumps, fire pumps, hot-water heaters, vacuum heating pumps, circulating pumps, steam and water mains, meters, control boards, gages and a host of auxiliary equipment too numerous to mention. At first glance one gains an impression of hopeless confusion. Closer inspection, however, dispels this illusion. Welded steel manifolds are used wherever possible and are located close to the floor with control valves readily accessible. The piping is laid out in its natural sequence so that the functions of the various controls are easily recognized.

The heating system has a total of over 3,800 radiators aggregating 136,000 sq.ft. of radiating surface. There are over eleven miles of supply and return heating risers, all concealed in the column furring. Expansion joints of the bellows type are installed about every 70 ft. of vertical height. Branches from risers to radiators are run exposed above the floor. All radiators are of the legless type, hung from brackets that are integral with the window frames. Fig. 4 shows how branch connections are made and how the radiators are installed.

The ventilating system of the building is divided into five classes of service: (*a*) Building toilets; (*b*) tenant spaces; (*c*) elevator machinery rooms; (*d*) auxiliary building spaces; (*e*) railroad spaces.

The building toilet exhaust system ventilates the men's and women's toilets throughout the office floors of the building. Each of these toilet groups has an independent sealed shaft with a separate exhaust fan connected at the top. Each fan has a capacity of 15,000 cu.ft. per minute and discharges to pancoast caps on the roof. Twelve changes of air per hour are exhausted from each toilet room. Fresh air enters the toilet rooms from the corridors through louvers in the lower panel of the doors.

Tenant Space Ventilation

Tenant space ventilation is of two kinds—private toilets and special spaces. Private toilets for tenants have been installed in numerous offices. Since the location of these toilets could not be predetermined, no provision was made to ventilate them. As these cases occurred, they were handled as separate units. Each toilet or pair of toilets has an individual small exhaust fan of about 75 cu.ft. per minute capacity. The fans, 28 in number, discharge through the nearest wall through special type metal brick vents. The ventilation of special tenant spaces is quite varied and consists for the most part of store ventilation. Under this heading the following spaces are ventilated:

1. Restaurant and kitchen.
2. Banking rooms, silver storage and safe deposit vaults.
3. Barber shop, beauty parlor and bootback stands.
4. Telephone booths.
5. Book stores, florist shops, stationery stores, haberdashers and drug stores.

Here again, it was impossible to provide in advance any comprehensive system to take care of the ventilating requirements of such a diversified list of tenants. The utmost that could be done to anticipate these requirements, was to provide ready means to install ventilation wherever required. This was done.

Two large shafts extend from the store ceiling level to the roof. The ducts to the tenants' fans in the roof penthouses were installed in these shafts. Tenants' supply fans are installed in tenant spaces. Fresh air is taken from the low level roof at the second floor level and filtered by sectional and automatic filters of the viscous oil type. Practically all fans have controllers of the push-button preset-speed type. This enables the tenant to start and stop his fans from his own space by push-button control. The push buttons are provided with signal lights to indicate the operation of the fans.

How Ventilating Difficulties Were Overcome

In some cases, such as the barber shop, the ventilating problem was very difficult. In this case building conditions made it necessary to place the supply air fan together with the filters and heaters in a shallow space between girders under the floor. Supply air is discharged into the shop behind the barber fixtures along two sides of the shop. On account of low ceiling height combined with extremely deep ceiling girders and beams, it was impossible to install ductwork at the ceiling. Accordingly, all air had to be exhausted from one end of the room, creating in effect a plenum chamber.

The ventilating systems of the stores have a combined capacity of 78,000 cu.ft. of air per minute.

The elevator machinery rooms have a separate supply and exhaust system. The high-speed elevator machinery generates a considerable amount of heat. This would quickly raise the room temperature to an extremely uncomfortable degree and seriously interfere with the proper functioning of the equipment. This is especially true in the motor-generator rooms. Each of these rooms contains eight motor-generator sets, one for each elevator in the bank. The amount of heat generated by these machines can be calculated to a nicety. The amount of air to be circulated to carry off this heat is also readily determined. This air has to be circulated mechanically, as no advantage can be taken of the ventilating effect of the elevator shafts. To do so would increase the objectionable up draft of the elevators at the lower floors. In the Graybar Building this chimney action has been neutralized and guarded against wherever possible. Accordingly, both supply and exhaust ventilating systems were installed with an excess of supply air.

Every elevator machinery room is ventilated. Each group of four motor-generator sets is served by a high-speed air nozzle 18 in. in diameter. These nozzles are near the floor, level with the top of the machines. They

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are of the swivel type and may be turned in any direction for convenience of operation and maintenance. About 8,000 cu.ft. of air is supplied to the machinery room of each bank of elevators. The supply air for this service is not filtered, but is drawn in at the upper penthouse level on the roof and blown down to the machinery rooms on the various floors below.

The auxiliary building spaces that are ventilated, comprise the main machinery room, elevator operators' room, carpenter and paint shops, paper storage room, steam reducing valve room and other miscellaneous spaces. All these spaces are served by a single exhaust fan of 15,000 cu.ft. per minute capacity in the fan penthouse.

The building entrance elevator lobby on the ground floor has a separate hot-blast supply air system. A fan on the mezzanine floor draws fresh air from the low roof above, through sectional filters and discharges heated air into the lobby below. In the lobby there are eight large grilles, one at the end of each bank of four elevators. Four of these grilles are served by large direct radiators. Four grilles serve the hot-blast system and discharge a total of about 10,000 cu.ft. of heated air per min. into the lobby.

The railroad ventilating system consists of a number of large metal ducts from the railroad shops and spaces under the Graybar Building. Some of these ducts are quite large, the largest being of sufficient area to permit four automobiles abreast to pass through. These ducts ventilate a large emergency lighting storage-battery room, paint and carpenter shops, electrical substation, track and other railroad facilities. Some of these ducts are connected to fans in the railroad space, and the remainder operate by gravity. For the latter, fanrooms have been provided on the roof, to enable the railroad to install fans should the need arise.

The building was erected by Todd, Robertson & Todd. The architects were Sloan & Robertson. The mechanical installation was designed and supervised by Clyde R. Place, consulting engineer.

A Reducing Valve That Failed to Work

By J. Jacobs

IN A city of about 40,000 population the local public utility conducted a steam-heating business in the down-town section. For a number of years the exhaust steam from three reciprocating engines was sufficient during most of the time, but occasionally was supplemented with a little live steam through a hand control valve. However, with the increase in the demand it became necessary to install a 4-in. reducing valve to control the admission of live steam to the 16-in. exhaust main in which the pressure varied from zero to 15 lb. per sq.in. The job of installing this valve was turned over to a pipefitter, and here is where our story begins.

The various screw and flange joints were made up properly, but when it came to running the small $\frac{3}{8}$-in. control pressure line from a point in the exhaust main back to the reducing valve, a distance of about 75 ft., he followed steam pipe fitting rules for heating systems in which every run of pipe must have a certain amount of "fall." All the steam that condensed in this 75 ft. of pipe drained back into the exhaust main. It looked like a perfect job, but the reducing valve failed to function.

Since the trouble must, *of course,* be in the valve itself, everyone who later attempted to correct it took the valve down, cleaned it thoroughly, although there was nothing to clean out, put it back together, and was greatly surprised when it failed to function. In order to make sure that the $\frac{3}{8}$-in. line was clear, the pipe was taken down and blown out, but still the valve failed to operate.

After all this I was somewhat hesitant to experiment before an audience, so at the first opportunity the union connection in the $\frac{3}{8}$-in. line at the reducing valve was opened under pressure only to discover that there was no pressure at this point, although at this time there was at least about 5 lb. pressure in the 16-in. exhaust main. This confirmed my suspicion prior to breaking the union joint. The $\frac{3}{8}$-in. pipe was acting like a very small condenser, so that little or no pressure was ever available at the diaphragm in the reducing valve, and the condensation was draining back into the exhaust main, just as the pipefitter hoped it would, but he didn't know why.

Acting on this discovery, a water seal was installed in the $\frac{3}{8}$-in. line at its connection to the exhaust main. This permitted the line to fill completely with water, which transmitted the varying pressures in the main to the diaphragm of the reducing valve. When steam was again turned on, the valve was found to function as it had been designed to do. This was a mighty small detail to upset a perfectly well designed reducing valve, and indicates how these same little details, that are so often overlooked, cause an endless amount of trouble.

What Makes Boiler Water Level Erratic

By R. P. Brockner

UNSTEADY water line is a difficulty occasionally encountered in steam-heating boilers. There are several causes that should be investigated, either when the water line is markedly unsteady or when the water actually leaves the boiler. In a new installation one may first suspect that the water contains considerable grease or oil under which circumstances priming may occur to such an extent as to cause a variable water level. In starting up a new system it is advisable to leave the return line disconnected for a considerable period, and to operate the boiler without return until all the oil used in making up the pipe joints shall have been washed out.

Another cause of erratic water level in gravity return systems is incorrect drainage of radiators and piping. Trouble from this source is probably more noticeable when starting up a cold system, since during this period condensation is most rapid.

Occasionally, conditions arise that cause water to back up into the return lines. This may occur when the steam piping is of inadequate size and the system is being forced, as it causes a high differential between the pres- water to back up in the returns.

ELECTRICAL
Operation and Maintenance

SPRING MOUNTING
Prevents Vibration From Frequency Converter

BY A. P. FUGILL
General Engineer, Westinghouse Electric and Manufacturing Company

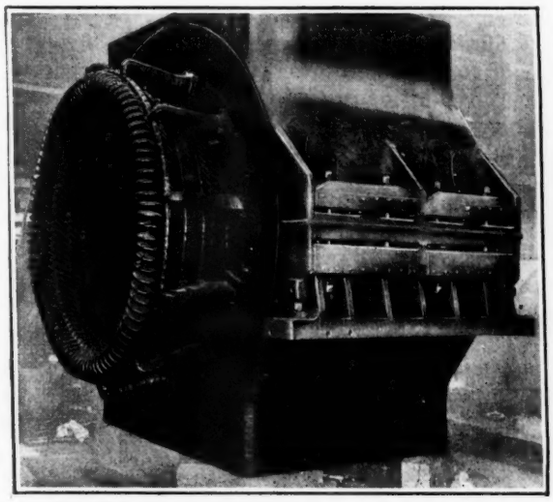

Fig. 1—Single-phase generator with spring mounting

TO INCREASE its power supply for electric train service out of New York City, the New York, New Haven & Hartford Railroad has recently installed a frequency converter. This unit, which has been located at New Haven, permits the supply of power from the local power company to the railroad system. One of the important features of this installation is the use of spring mounting on the single-phase generator, which has a maximum rating of 10,700 kva. Spring mounting for single-phase generators is not new; in fact, the first generator with this feature was put into service by the Westinghouse company in 1923, and spring mounting was fully described in the technical press in 1924.[1]

Owing to the limited application of single-phase generators, however, comparatively few units with this feature are in operation, and this New Haven machine is one of the largest units which is normally being operated on single phase. Other spring-mounted machines of much larger rating have been installed, but because the present demand for single-phase power from these machines is not large, they are now being operated three-phase.

Spring mounting, which means that the stator is mounted in a flexible manner, is used to absorb vibration inherent to the machine and prevent it from being transmitted to the foundations. It may be that the question arises, "Why is spring mounting necessary for single-phase generators of this type when it is not required for three-phase units?" It is entirely a question of generated torque, which is constant in three-phase machines but pulsating in single-phase equipment. In all electrical generators there is a reaction between the armature current and the flux in the field poles, which is called the generated torque. This torque is proportional to the current and, therefore, exists whether the machine is carrying a kilowatt load or merely floating on the line supplying reactive kilovolt-amperes.

It is well known that in a three-phase induction motor, for instance, there is set up in the stator a magnetic field that is constant in magnitude but rotates in space. In a single-phase machine the magnetic field is fixed in space but varies in magnitude from a maximum in one direction to a maximum in the opposite direction. In like manner, the generated torque in a three-phase synchronous machine is of constant magnitude and always in one direction, while the generated torque in a single-phase machine is cyclic, varying both in magnitude and direction.

This pulsating torque acts like a giant hand which grips the stator and tries to rotate it first in one direction and then in the other, fifty times each second for a 25-cycle system. Naturally, the result is vibration. This vibration is inherent to single-phase generation and cannot be removed in any way. Therefore, the alternative is to prevent it from being transmitted beyond the machine to the foundations and the station. This is done effectively by flexibly supporting the stator in properly designed and adequately proportioned springs.

But someone conversant with railway practice says, "For many years now, single-phase turbine generators have been used and no spring mounting has been applied to them. Why the difference?" Two factors enter in; namely, the magnitude of the unbalanced forces and the inertia of the stator, which, being a mass at rest, resists any tendency toward motion. Actual motion of the stator—very minute, of course—must occur to produce vibration. If the giant hand or unbalanced torque is

[1] "Vibration Absorbers for Large Single-Phase Machines," C. R. Soderberg, *Electric Journal*, August, 1924.

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weak or, conversely, if the resistance of the stator is great, very little vibration can result. Therefore, the amount of vibration depends upon the proportion of produced torque to stator inertia.

Turbine generators are usually built at higher speeds with consequently lower torque per horsepower and use more rigid construction throughout than a corresponding salient-pole machine. Hence in the turbine generators built up to the present time the proportion of produced torque to stator inertia is small, vibration is not excessive and spring mounting is not necessary. Likewise, in machines of small capacity spring mounting can be dispensed with. In general, the necessity for flexible support of the stator increases as the machine speed decreases and as the machine rating increases. Thus it comes about that for practically all frequency converters of moderate or large size, feeding single-phase load, spring mounting is considered necessary and undoubtedly will be used in the future. In addition, it is probable that this feature will be incorporated even in turbine generators if those units are of very large size.

It may be of interest to know just how this spring mounting is accomplished on the machine recently installed at New Haven. The two general classifications of springs are the beam and the spiral types. At the time the original research work was done, more than five years ago, both types of springs were considered and after considerable study the simpler and more rugged beam spring, made of flat spring steel, was chosen as best adapted for this service. Subsequent experience in actual operation has borne out the wisdom of this choice. The springs, of course, must be properly designed to

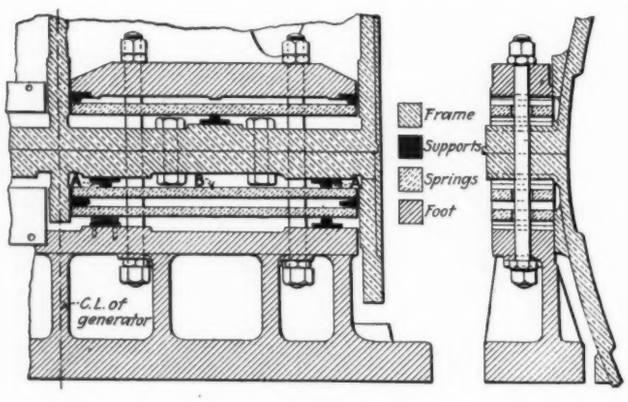

Fig. 2—Spring assembly on single-phase generator

work with the particular machine so as to be most effective, but the results of tests similar to those mentioned later have shown that the effectiveness of the springs in operation can be predicted from the analytical design data with a good degree of accuracy.

In the New Haven machine this spring mounting is accomplished as shown in Fig. 2. On each side of the generator the spring assembly consists of six pieces of flat spring steel. The only mechanical connection between the stator and the feet is the assembly of springs and spring supports. It will be noticed that the stator rests on spherical supports *A* which bear on the upper spring *B* of the lower pair of springs. This pair of springs, which have wedge-shaped supports between their ends, rest in turn upon other spherical supports bearing on the frame feet. Thus the whole weight of the stator is carried through the springs. The spring above the frame projection acts as a snubber to prevent any tendency toward bouncing. The through bolts hold the whole assembly together without in any way interfering

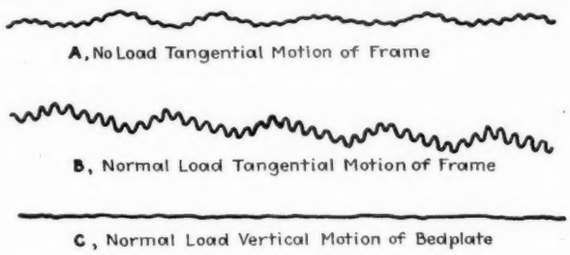

Fig. 3—Test results of vibration on single-phase generator

with the flexible support. Fig. 1 shows the actual appearance of this machine.

This machine has been installed only a short time but the tests that have been made show that the spring mounting effectively prevents the transmission of vibration to the foundation under any conditions that will be imposed upon it in service. Typical results of these tests are shown in Fig. 3. These tests, which were made with sensitive vibration recording equipment developed for this kind of testing, show the tangential motion of the frame under no load, Fig. 3*A* and rated load, Fig. 3*B*, plotted against time. Fig. 3*C* shows the vertical motion of the bedplate near the frame feet and indicates how well the vibration in the frame is damped out.

These tests, however, merely corroborate data previously obtained on other machines that have been provided with spring mounting in the past. Spring mounting of this type has long since passed the experimental stage, and there is little doubt that practically all single-phase generators of the type and size where vibration is important, will in the future be thus equipped.

Preventing Insulation Breakdowns in Commutators

By W. E. Warner

QUITE a frequent cause of breakdown in direct-current motors, generators and rotary converters is the collecting of copper and carbon dust on the surfaces at the back of the commutator. Owing to the fanning action of the end windings, this dust is readily drawn through the risers and deposited behind the commutator. With soft-graphite brushes this trouble is more likely to occur, as the brushes wear quite fast and the greasy nature of the dust makes it adhere readily to any surface.

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When the surface behind the commutator is rough or when oil, which escapes from the bearings, makes these surfaces greasy, the dust will adhere more readily, and if allowed to continue, it is only a matter of time before breakdown occurs. This trouble may be prevented by arranging a cloth over the commutator risers to prevent dust being carried through them. As this largely prevents the passage of air into the armature, it will cause an increased temperature rise, which may render this method impracticable.

I have found that good results can be obtained by using a thin muslin through which a certain amount of air circulation is possible. This is secured by weaving it between the riser bars and connecting the two ends by sewing. Then with a small brush apply a little paste on the muslin immediately in front of the risers. If the cloth is thin, the paste will penetrate and stick it to the bars. This will reduce the possibility of its working loose.

The major part of the dust is drawn through the bottom half of the bars, and the muslin covering may be extended only halfway up the risers, the top half being left free to permit circulation of air. This will largely prevent the passage of copper and carbon dust. Any dust that collects on the muslin should be cleaned off. An old tooth brush is convenient for this purpose.

The method of insulating the inner V-ring on many machines leaves a lot to be desired; the insulation is sometimes finished off flush with the ring. The insulation should project slightly and be well covered with insulating varnish so that no bare part is exposed. Frequent blowing out with compressed air is advisable to remove any dust that does collect.

Was Electrolysis the Cause of the Water-Pipe Failure?

By George I. Mackenzie

ONE morning a building cellar was found partly filled with water and the water was still pouring in from the direction of the street. A plumber was called and upon digging down to the water supply pipe he found that the lead-in pipe was completely broken off about midway between the water main and the building and also midway between two joints.

A further investigation revealed that the electric light company's underground distribution cables were located approximately one foot below the lead-in pipe and directly under the spot where the pipe failure occurred. This fact, together with the knowledge that the water pipe was being used for grounding the power system, prompted the consumer to enter a legal suit against the electric light company.

The electric light company sent out testers to investigate the problem, and numerous tests were made in an effort to locate any electrical leakage that might be responsible for the pipe failure. The section of pipe that failed was ordinary lead pipe commonly used as a lead-in from the water main to the house. The underground cables were lead covered, installed in fiber ducts and carrying a maximum potential of 220 volts. The meter ground wire was clamped to the water pipe in the cellar, and the result of both a direct-current and an alternating-current ammeter reading showed that no current was flowing in this wire. There had been no unusual voltage condition on the secondary at any time preceding the failure, and no potential could be detected at any point that might be considered as a possible source of trouble.

Electrolysis tests were made, but the results showed the locality to be relatively free from electrolytic action. An examination of the pipe section that had failed provided no clues to aid the investigators, because the broken ends of the pipe gave the indication of a purely physical break.

There were no high-tension electric lines installed anywhere along the street, and there was no vibration due to trolleys, railroads, trucks or buses, therefore while the test results eliminated all possibilities except a physical failure, still it would be difficult to conjecture what would cause a physical fault. The pipe has been in service over three years and any flaw must have developed after the pipe was installed. Owing to a lack of evidence the legal action was withdrawn and the actual cause of the failure is still an unsolved problem. Perhaps some interested reader will venture an opinion on the subject.

Excessive Heating of Slip-Ring Motors Resistance

By T. R. Hinton

A PECULIAR trouble occurred in the maintenance of two electric cranes equipped with three-phase alternating-current motors and controllers. The operator was complaining of excess heating of the resistance in the rotor circuits. In the investigation it was noticed that the motor driving the double cable drum, which carries

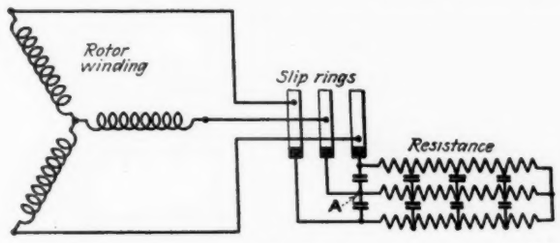


Diagram of rotor circuits

the major part of the load, seemed to vary in speed with the controller handle stationary. As the hoisting drum is low-speed, the change was easily noticed from the noise of the gears.

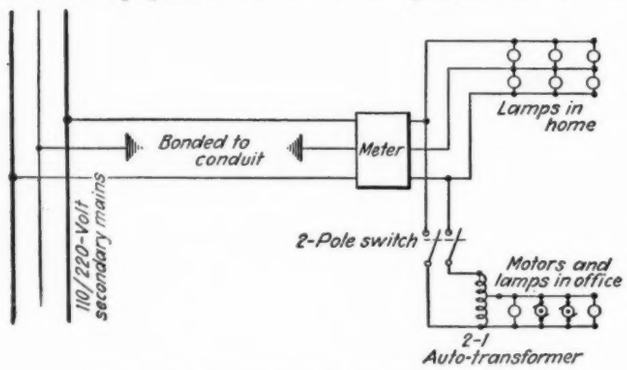
The trouble was found to be caused by one lead from the rotor to the resistance being loose, such as at *A* in the figure, consequently there was an open in one phase in the rotor, which unbalanced these circuits. The two banks of resistance left in the circuit had an overload and caused the excess heat. The trouble was repaired and conditions were normal again.

ELECTRICAL *Operation and Maintenance*

Use of an Auto-Transformer

MAURICE D. SMITH

UTILIZATION of the 2-1 auto-transformer as a remedy for flickering lights is common, but a unique case arose a short time ago and may be of interest to those dealing with voltage complaints. An investigation indicated that several 110-volt electrical machines installed in an office caused the complaint, and replacement with 220-volt equipment was out of the question as the cost



Auto-transformer for office motors improves lighting service

was prohibitive. The distribution system was underground and had been in use several years, and the service leading from the street to the customer's meter consisted of two No. 8 wires connected for 100 volts and drawn in a ¾-in. conduit. To pull these wires out and replace them with three wires was impossible on account of the time they had been in the ground.

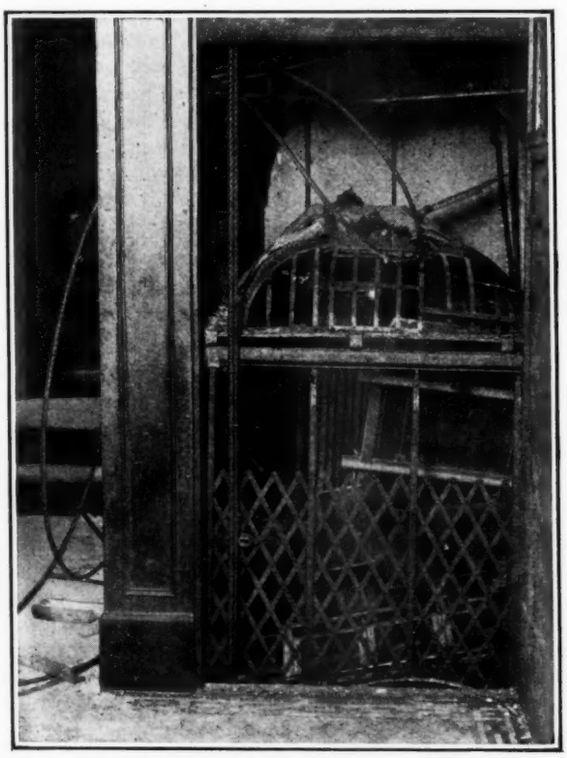
Use of the auto-transformer was then considered, and an economic study showed it to be the cheapest; it was therefore installed as shown in the figure. The two service wires were reconnected for 220 volts, and the neutral in the street was bonded to the conduit and run to the meter. The house lighting load was balanced on 220 volts as shown, and a 2-wire 220-volt circuit was run to the office containing the motors. This installation worked satisfactorily and stopped the lights flickering.

This Elevator Accident Could Have Been Prevented

IT IS safe to say that every accident teaches a lesson. If all the knowledge derived from past accidents of various kinds could be assembled, published and impressed upon the public consciousness in such a way that it would be remembered and put into use, the result would be of incalculable benefit to the human race. Many accidents (probably most of them, in fact) are due to simple causes—to the failure to take some obvious precaution, to momentary forgetfulness, absent-mindedness or inattention, or lack of appreciation of the hazard.

The accident shown in the figure appears to be assignable to this class. The superintendent of a building and the elevator operator were assisting a truckman in moving a machine on to the elevator at the first-floor level. In the course of the operation a protruding part of the machine came in contact with the elevator controller handle and swung it over to the starting position. The elevator moved upward and a part of the machine became wedged under the floor saddle at the second floor. This caused so great a strain on the elevator-hoisting cables that they pulled out at the crosshead. Consequently, the elevator dropped, but fortunately, the safety device operated properly and the elevator stopped about four feet above the bumpers at the bottom of the shaftway.

It is said that an emergency switch (sometimes called a "baby" switch) was installed on this elevator. It is hard to understand how the accident could have occurred if this emergency switch had been opened and had been left open until the machine had been properly placed on the elevator. If it is true that the switch was not opened, the accident affords an illustration of failure to exercise a simple and obvious precaution—with resulting property damage. We do not know whether the failure that is here assumed was due to forgetfulness or to lack of



The results of an elevator accident

appreciation of the hazard, or was merely another example of the all-too-common chance-taking habit. If any of these possibilities were really responsible, it is quite unlikely that the persons directly concerned will be involved in a similar accident in the near future, if ever. They will have learned their lesson—let others benefit from it.—*The Travellers Standard,* Hartford, Conn.

REFRIGERATION
Equipment and Operation

Modern Methods of Freezing Tank Operations*

By J. R. BEREND, SR.

A Discussion of the Action of Ammonia in Evaporating Coils—An Explanation of Why Ice Fractures—Outline of a New Design of Coil

THE freezing tank and freezing tank coil have been with us ever since the first time ice was produced in an ice can. The ice making capacity of the tank has always been rated by the freezing time of a can and by removing the block of ice from the can without cracking, and the cracking of a block of ice is governed by the brine temperature.

I have never been on the inside of a brine tank coil, and the conclusion I have drawn may be all wrong. However, I will say that the plant I am operating, and where I derived these conclusions which I am giving you here, made 180 tons of ice in 24 hours with 15-deg. brine and cracked a good percentage of the ice the first season the plant was operated. For the last three years we have been making 205 tons for periods of seven days with a brine temperature of 12 deg. and 40 hours freezing time, with a small percentage of cracked ice. As that is an increase of 25 tons of ice per day, I thought maybe it would interest plant owners and operating engineers.

In case of a cake of ice that subsequently cracks, we find that if the brine is carried at 15 deg. F., the can freezes solid from the bottom halfway up in from 18 to 20 hours. The hole at the top of the can is 5 to 6 in.

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Fig. 1—Tank top of Fulton ice plant of which the author is chief engineer

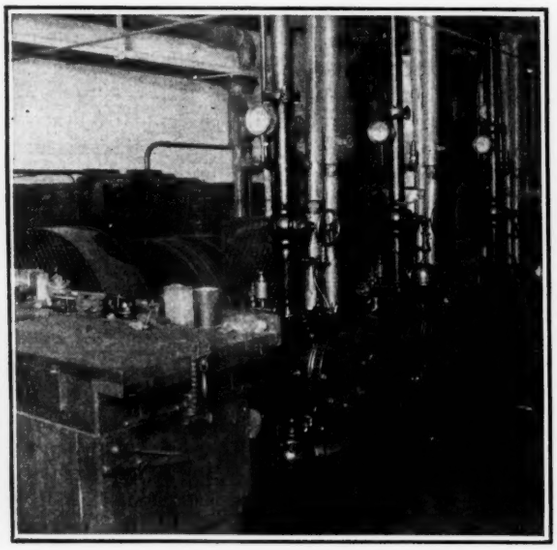


Fig. 2—Compressor used to supply agitation air

REFRIGERATION *Equipment and Operation*

wide, and it takes from 20 to 24 hours longer to close. During this time the lower half of the ice will take on the temperature of the brine, while the top of the ice will be 28 to 30 deg. when the can is finished. When ice of such unequal temperature is lowered into a thaw tank containing water of 60 deg., it will crack.

Now why does the lower part of a can close in less time than the upper half? There is only one reason that I can find and that is, because the lower part of the tank is colder than the upper part, brought about by insufficient ammonia in the coils. When an operating engineer governs the amount of ammonia he has in the tank coils, by the temperature of the suction at the compressor, two or three coils spilling over will give him the desired suction temperature, while the rest of the coils will be only half full or not circulating.

Operating engineers take for granted that a liquid header is full of liquid when the tank is being operated. That is not the case. The only outlet to the header is at the side where the coils connect into it. If the liquid coming from the receiver is at 80 deg. F., 16 per cent of the liquid evaporates to refrigerate this liquid to the coil temperature and must pass through this header, and the upper part of the header is always full of gas to the coil opening. If the liquid header and the coil openings are perfectly level, each coil would get the same amount of liquid and gas and if the amount of liquid going to the coils is sufficient to spill over at all times, all the coils will produce the same temperature in the brine tank at the top as at the bottom of the tank.

If the liquid header is out of level, the coils at the high end will receive all the gas produced between the expansion valve and the liquid header, and that side of the tank will fall behind. And again, we know that the liquid header traps oil, as oil is heavier than ammonia, and it will fill the header to the lowest coil opening and enter the coils at the low end of the header. When the lowest pipe of the coil fills to the first return bend, the coils will cease working until enough coils become filled with oil to disturb the pressure balance and force some of these lazy coils to work, but not all of them. Some of the coils may remain idle throughout the season.

A tank operating under these conditions will not freeze all the cans in an equal time. As the pulling is governed by the slowest freezing time, cans that will freeze in less time will take the temperature of the brine and crack, while the cans that are taken out as soon as they are frozen will not crack. To overcome this unequal freezing, increased brine circulation has been resorted to. To my way of thinking, it has made matters worse. The brine circulation is always greater in the lower part of the tank than in the upper, as there is more room there and less friction, for the can surface is more than double the coil surface. We double the heat transfer at the lower part of the can where we do not need it, and if the upper pipe of the coils contains no ammonia, it will not close the upper part of the can any quicker. The only thing we can do is let the brine temperature come up to where the ice will not crack and lose in ice output.

To keep coils full of liquid at all times is not as simple as it appears to be. We cannot regulate that with the expansion valves, even though the liquid header and coil openings are all on the same level and no oil and bad liquid are in the system. Unless the compressor is the proper size, if brine temperature goes below the temperature at which we wish to operate, we must curtail the liquid at the expansion valve and the coils will cease to spill over. The upper pipe of coil will become empty and do no work. On the other hand, if we could reduce the compressor capacity and maintain the proper suction pressure and reduce the temperature difference, the brine temperature will rise and keep the coils spilling over. For it is not the quantity of ammonia alone in the coils that determines the brine temperature; it is the suction pressure, the temperature difference and the pipe surface we cover with liquid that determine the temperature of the brine. These three conditions cannot be maintained with the expansion valve alone; the compressor capacity must be varied accordingly.

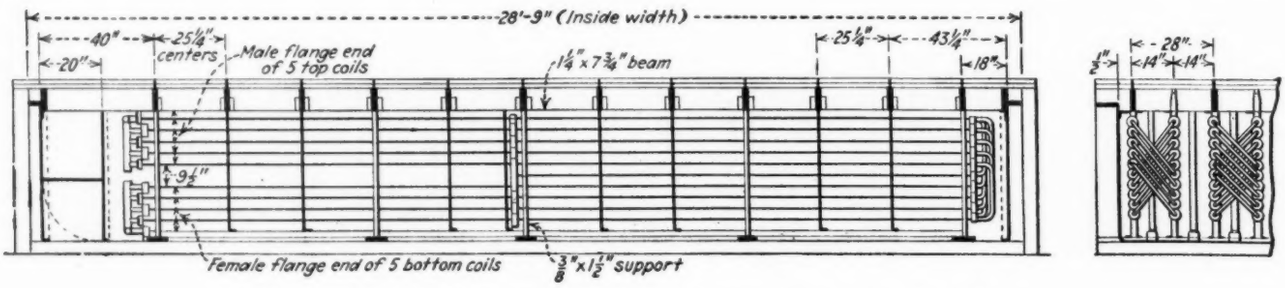


Fig. 3—Layout of the new design of coil recommended by the author

The plant I am operating has four freezing tanks. The coils consist of ten 1¼-in. pipes. These coils are grouped, four and five coils to the group. Each group has an independent suction header provided with a stop valve at the header. When one of these groups lags, we close the stop valves on the lively group and force the lazy groups to remove any oil or lazy liquid that collects in them, and it takes only a few minutes to do that. We can operate continuously and freeze all the cans in the same length of time, and operating with 12-deg. brine, we have but a very little cracked ice. But when the pulling is interrupted for an hour or such a matter, we get cracked ice until we catch up again.

REFRIGERATION *Equipment and Operation*

However, there is one bad defect in a 10-pipe 1¼-in. coil 65 ft. long that we cannot overcome by operating methods. A coil of these dimensions operated at a coil temperature of 5 deg. F. and a temperature difference of 8 deg. F. has three pounds pressure difference between the liquid header and suction header.

This pressure difference is caused by the friction of the gas and liquid in the coils. The pressure difference between the upper and lower pipe does not remain constant; it varies with the rate at which the tank is being operated in terms of tons of ice per day or pounds of liquid circulated per minute.

It is possible to design a coil to eliminate this pressure difference; one of these coils is shown in Fig. 3. It will be noted that the coil is divided into two separate groups per coil, each group containing five 1¼-in. pipe connected to a liquid manifold and to the suction manifold in the upper group. In this manner the gas travels only one-fifth as far per coil as it does in a 10-pipe hairpin coil.

This manner of construction will not materially increase the best transfer per square foot of pipe, as is claimed for some group coils we hear about. The one actual advantage in its use is to reduce the pressure difference to a very small amount, therefore, allowing the tank to be operated with a suction pressure nearer the brine temperature than is possible with the hairpin-type coil.

By placing an accumulator in the suction line and connecting the liquid return line to the liquid headers, the coil can be operated flooded without any danger of getting liquid in the compressor cylinder. The liquid going to the expansion on valves is cooled in a coil installed in the accumulator through which the liquid passes on its way to the expansion valve.

This coil was tried out in a tank containing 480 cans of 300 lb. each. Ordinarily, a tank of that size is charged with 1,500 lb. of anhydrous ammonia, but this one was charged with 2,200 lb. Operated with a brine temperature of 14 deg. and a suction pressure of 25 lb. gage, 38 tons of ice was harvested in 24 hours, with a condenser pressure of 210 lb. The liquid was cooled to a temperature ranging between the saturated temperature of the suction pressure and the brine temperature. The suction temperature at the machine was easily maintained at about 10 deg. superheat. This tank has been in service continuously for the last two years and is operating satisfactorily in every respect.

Leaks in Automatic Plants

ON AN automatic installation the expansion valve should be shut off completely, at about the same time that the machine is shut off, according to F. R. Erbach, in *Refrigerating World*. If the valve holds, the back pressure will rise very little during the shut-down period. When the machine again starts up, it will have no difficulty in starting, because the suction pressure is low and the regular starting load is thrown on the motor. If the expansion valve had leaked, the refrigerant would continue to flow into the low side, causing the suction pressure to rise and practically equalize pressures in the system.

When the machine starts under these conditions, an excessive load is thrown on the motor. In addition, there is danger of possible leaks through the crankshaft packing box. Belts are likely to stretch or slip owing to the excessive starting load. If the expansion coils are not properly designed and a leaky valve is used, there is often danger of a severe liquid knock—just as the compressor starts and begins to pull gas from the low coils, some of the liquid is pulled over and gets to the compressor. Liquid returning in this way has been known to cause serious damage, by cracking or springing the suction and discharge valves. Some of this liquid will find its way to the crankcase, and, in evaporating in the presence of the agitated oil, will cause the compressor to pump oil rapidly. This also may cause knocking.

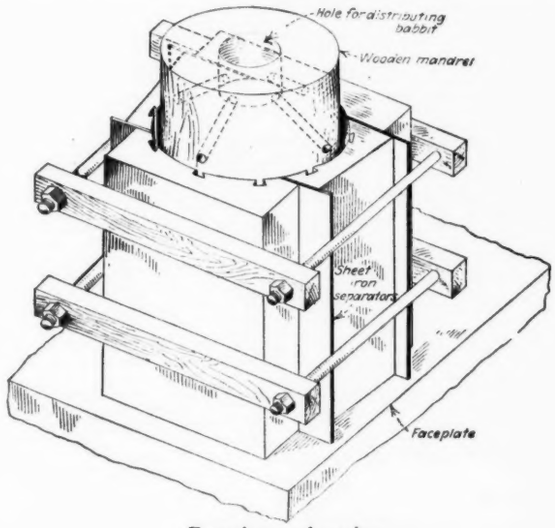
There are a number of installations of automatic equipment which are controlled by a thermostat on the suction line.

Pouring a Four-Piece Adjustable Bearing

By H. C. Cunningham

A BURNED-OUT ammonia compressor bearing in an ice plant with only one compressor means a rush job in repairing the bearing. We rigged the bearing in the following manner to pour babbitt.

First, we turned a wooden mandrel to the shaft size



Pouring a bearing

and about four inches longer than the bearing. Then four holes were bored in the mandrel, as shown in the illustration. The four pieces of the bearing were then set on a surface plate and pieces of sheet iron inserted at each joint in such a manner as to act as centering spacers for the mandrel and separators for the babbitt. The whole bearing was then securely clamped with wooden clamps. A thin layer of fireclay was placed on the surface plate to set the bearing on. The method of pouring proved highly satisfactory.

EDITORIALS

Byproducts of Central Stations

THE principal purpose of the modern steam central station is to develop electricity cheaply and reliably. All recent stations have had this single objective in view, and rapid strides have been made during recent years in improving both the design and efficiency of such plants. It is now possible, by means of high pressure, high steam temperatures, reheating, bleeding and low condenser pressures, to develop a kilowatt-hour from one pound of coal. It is quite within reasonable expectation that even better performance will be secured on some future steam stations within a short time. The use of mercury boilers and turbines superimposed on the regular steam plant presents further possibilities in high station efficiency.

In all of these stations an attempt is made to get the maximum power from the steam that it is capable of delivering. While the results noted indicate a rate of progress that should be satisfactory to engineers, one cannot help asking whether our central station owners and designers have been so preoccupied with the idea of electrical development only, that they have not fully considered possible sources of byproduct revenues which might yield still greater returns than electricity alone, or which might enable the electricity itself to be generated at a still lower cost. Central district heating is an example of such byproduct use of steam that will occur to everyone. The exceedingly low heat consumption of power generated by turbines acting as reducing valves to steam heating systems, is well known. Some progress along this line has been made in isolated cases. One problem with central steam heating is its seasonal nature and the long periods of idleness in the summer.

Much thought has been devoted to the possibility of giving the raw coal to the furnaces a pretreatment such as low-temperature distillation before burning. The byproducts of gas, light oils and tars thus recovered have a high market value. It is hoped that their sale will lower the cost of fuel and thus decrease electrical generating costs.

Other byproduct recovery schemes, such as the sale of ash for cinder-blocks, etc., yield some revenue in certain cases, but the effect of this on power cost is small.

After midnight every central station system experiences light loads. Suppose plants for electrolytic processes such as the generation of oxygen and hydrogen or units for the production of calcium carbide, acetylene, dry ice or other chemical processes were constructed as adjuncts to power plants to consume offpeak power. Markets are developing for many such products in all our large metropolitan areas. These products should at least pay for themselves, while the fact that their use increased the daily load factor would assist in lowering the cost of power.

These are merely tentative suggestions and may not be suitable in many places. Their main object is to emphasize the idea that central station development has about reached the point where further reduction in the cost of electricity will come largely through the effect on production cost of the development of certain byproducts to the central station itself.

Skepticism and Inventions

POLLYANNA and Babbitt have left so deep an impression on the American character that we have forgotten that a certain degree of skepticism is good not only for our souls, but likewise for our purses. This bit of wisdom applies most strongly when the subject under scrutiny is a declared revolutionary invention.

Unlike a horse race, time is of little importance to the natural sciences, and history fails to record a single instance of the element of speed in the development of any new physical principle. In the case of the electric motor it was years, even decades, between Faraday's experiments and the production of a practical machine. Consequently, engineers may well ask to be shown when an inventor proclaims that he has discovered a new principle and has within a few years developed a working machine. Especially is this true when the apparatus takes on the garb of a perpetual motion machine or is claimed to make use of free energy.

Newspaper reporters, by the variety of their experience with sophistry, should be inclined to sprinkle the traditional grain of salt upon the publicity efforts of promoters of such things as fuelless motors. A less intense desire to tempt the appetite of readers with the unusual would have prevented the leading papers from filling column after column of expensive news space with hazy accounts of this fuelless motor which, it is claimed by its inventor and backers, makes use of the magnetic flux of the earth to develop power. Notwithstanding the statements of various scientists that the energy from this magnetic fuel is so weak that no power could be obtained, the press has, by implication at least, led its readers to believe that the machine works as claimed. If at a later date it is found that people have been induced

by the reporters' glowing reports to invest, it is questionable if the press can declare itself morally blameless.

Power has at various times investigated a number of perpetual motion machines and free energy machines, but in no case has such an apparatus been found capable of delivering power. As a result the fuelless motor is viewed with a considerable degree of skepticism, and even rank disbelief.

[Since this editorial was written, F. W. Hochstetter, at whose laboratory the early models of the Hendershot fuelless motor were built, has publicly declared the motor to be a fraud and that it is driven by a concealed battery.]

Why the Inconsistency in Wire-Rope Life?

PROBABLY the most erratic thing that the engineer has to deal with is wire rope. In one building elevator hoist-cable life for high-rise cars varies from seven thousand to nearly fifty thousand car miles. On the low-rise cars the hoist-cable life ranges from less than six thousand car miles to nearly thirty thousand. When a set of cables installed costs five hundred dollars and one gives seven times the service that another does, there is an expense involved that makes the problem of vital interest to those who are responsible for the elevator.

Millions of dollars per year could be saved by obtaining long life from elevator cables. However, an analysis of cable records shows no consistent wear. In some cases the life of successive sets of cables will increase, while in others the life will decrease. For still others no systematic relation seems to exist.

The conditions under which elevator cables operate vary. The grooves in the sheave wear, not only in shape but also in the diameter about which the cable travels. One groove may wear faster than the others, which will cause the cable that runs in this groove to slip. The brake adjustment and the operator both affect the life of the cables. The care taken to have the cables equally loaded and to maintain the division of load has an influence on their life. These conditions, however, can account for very few of the wide variations in cable life, for the life of governor cables varies over a range comparable with the hoist cables.

Although it probably has not been definitely established, there appears to be good reason for the belief that a great deal of the trouble is in the cable itself. The unequal stretch in a set of new cables seems to bear out this contention. One cable in a set has been known to stretch eighteen inches more than the others in a few weeks.

The trouble with most of the information on cables, obtained in practice, is that the conditions vary to such an extent that a deduction made from the data is not likely to be conclusive. There is an opportunity for some organization to undertake a study of the wide variation in cable life. To have this done properly, it should be carried out by some disinterested body such as one of the universities, the engineering societies or the Bureau of Standards. The work is of such a character that it will require a period of years to complete, and considerable cost is involved. This, however, is justified by the savings to industry possible through an understanding of the factors that influence the life of wire rope.

Imagine the Savings!

IMAGINE what a difference it would make in the cost of process heat in some industrial plants if the heat-using equipment were properly insulated. Insulation of steam lines in the power house is such standard practice that the management accepts its necessity without ever seeing the lesson therein as to the need for insulating steam-using equipment.

Insulation should be installed where it is needed, and it may be as uneconomical to install too much as too little. Where to use it and what type to use require judgment and experience. The power engineer is the one man in the plant fitted by training and practice to take care of the insulation, and the production department would do well to see that he does.

If the management of the plant using insufficient or incorrect insulation could be brought to recognize that fuel saving is not the only advantage that follows proper insulation, but that improved production from better heat application is also obtained, they would not be long in acting. And when all managements do realize this and put the use of insulation in the manufacturing departments in the hands of the power engineer, imagine the savings that will be made!

Checking Operating Thermometers in Place

THERE are several plants in which thermocouples have been permanently installed adjacent to the sensitive elements of the recording and indicating thermometers that are used as guides in regular plant operation. By means of a portable instrument occasionally connected to the thermocouples, the operating instruments are checked and adjusted.

The cost is said to be about fifteen dollars per thermocouple, plus the cost of the portable instrument. It should be worth more than this to know that the instruments on which plant records and operating guidance depend are yielding reliable information.

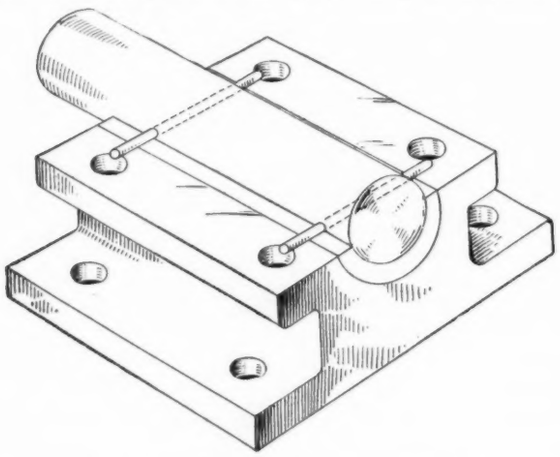
IDEAS *from* PRACTICAL MEN

Readers are urged to use this department for the exchange of practical operating information. A minimum of five dollars will be paid for contributions accepted

A Babbitting Arbor

A METHOD of rebabbitting bearings is shown in the illustration, in which a babbitting arbor, self-locating from the top of the box to the bottom, is used.

In the ordinary run of babbitting a great deal of time is lost in locating the shafting by using little pieces of



Suggested method of locating arbor

leather or wood, to raise the arbor so that the largest diameter is at the top of the boxes.

For the babbitting of small sizes of bearings two holes are drilled in the arbor to receive two pins which are a sliding fit. The bearing cap in turn can be babbitted after removing the pins and turning the arbor upside down.

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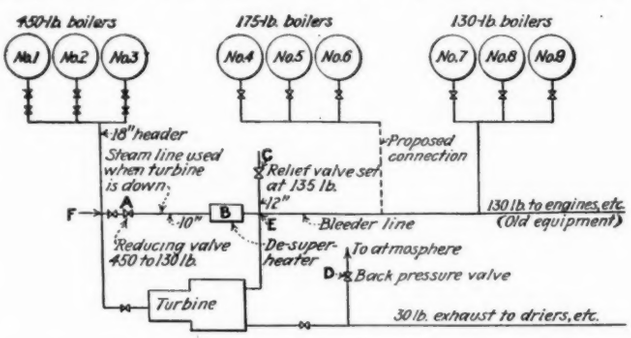
How Should High- and Low-Pressure Boilers Be Interconnected and What Safety Devices Are Necessary?

BECAUSE of the inception of high pressure in power plants, it frequently becomes desirable to utilize steam from high-pressure boilers to operate low-pressure equipment. This often involves a change in the layout of piping and installation of valves and other accessories usually found unnecessary where the entire plant is new and the equipment operated under one pressure. In contemplating a plan of operation, new problems frequently present themselves to the engineer, the responsibility of which he does not care to assume, hence passes them on to others, hoping to find a proper and safe solution of his difficulties.

The accompanying sketch will serve to illustrate one of the problems recently submitted to me. It will be seen that this plant has three batteries of boilers, operating at 450, 175 and 130 lb. respectively. The three 450-lb. boilers were recently installed and are intended to furnish steam for two new turbine units at full pressure, they having replaced two old horizontal tubular boilers at 130 lb. pressure. It is desired in this case to use the steam from boilers Nos. 1, 2 and 3 to operate the old equipment in the event of a breakdown to the turbines. Provisions were made for this operation by installing a 10-in. steam line from the 18-in. header at *F* with a 10-in. reducing valve at *A* and a desuperheater at *B* and the 12-in. steam line to the bleeder line at *E*. To this line is connected a 12-in. relief valve at *C*.

The questions involved are: (1) What provisions should be made to relieve any excess pressure in the bleeder line in order to protect the old equipment in event the reducing valve fails to function? (2) Will the 12-in. relief valve *C* be sufficient to do this? If not, and if necessary to afford further protection against excess pressure, should safety valves be installed? (3) If safety valves are necessary, how many and of what size and relieving capacity should they be and where should they be located to be most effective; ahead of the de-



Suggested arrangement of interconnecting boiler operating at different pressures

superheater or back of it? (4) What consideration, if any, should be given the low-pressure boilers?

Venturing a solution to this rather involved problem, it is my judgment that the arrangement of piping as shown in the print will be satisfactory; however, there should be a 3-in. superheater-type safety valve of high relieving capacity installed in the 10-in. steam line immediately following the reducing valve. This valve in combination with the relief valve at *C*, should be ample protection against any excess pressure that may come as a result of the reducing valves failing to function. Some-

times, in instances of this kind it would be advisable to employ a reducing valve smaller than the steam pipe. We should say in this case a 6-in. reducing valve would furnish sufficient steam and it would have the effect of throttling the high pressure and would eliminate to some degree the constant opening and closing of the reducing valve due to the pulsation of the reciprocating engines on this line. This, of course, would require that the 6-in. valve have a flange connection to fit the 10-in. pipe flange.

As an alternative arrangement, it may be possible under conditions of this kind to employ two reducing valves, the first to step down the pressure about 50 per cent and the second to the pressure required. In the event two reducing valves are employed, it would seem unnecessary to install a safety valve, as the liability of failure to the reducing valve would now be reduced 50 per cent and under any conditions likely to occur, the back pressure valve should be adequate to take care of any excess pressure. However, in either case where other boilers are connected up to this line as is indicated in the sketch, it appears more important that the headers to these boilers be equipped with automatic non-return valves in addition to the regular header valve to afford protection against any excess pressure due to any possible failure of this arrangement.

It would be interesting to hear from readers of *Power* who may know of similar conditions and what arrangements were made and the success or failure of the plan.

Chicago, Ill. F. C. FOSDICK.

Short Cuts to Water Treatment

TO SIMPLIFY the work of the boiler-house chemist, particularly those who are chemists part of the time and operators most of time, the following tables are suggested. They eliminate some of the calculations that would otherwise have to be made.

While perhaps not suited for highly accurate determinations of a regular analytical laboratory, for the usual boiler plant burette they are a help. These tables concern only the acidity of the water and lime treatment for neutralization.

Table I gives directly the acidity of the water for various quantities of standard solutions required to neutralize. While it is based upon standard solutions of one-tenth normality, similar tables could be derived for any normality.

TABLE I—CUBIC CENTIMETERS OF ALKALINE SOLUTION USED

	0	1	2	3	4	5	6	7	8	9
	Parts per Million Acidity									
0	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
10	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5
20	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5
30	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5
40	20.0	20.5	21.0	21.5	22.0	22.5	23.0	23.5	24.0	24.5
50	25.0	25.5	26.0	26.5	27.0	27.5	28.0	28.5	29.0	29.5
60	30.0	30.5	31.0	31.5	32.0	32.5	33.0	33.5	34.0	34.5
70	35.0	35.5	36.0	36.5	37.0	37.5	38.0	38.5	39.0	39.5
80	40.0	40.5	41.0	41.5	42.0	42.5	43.0	43.5	44.0	44.5
90	45.0	45.5	46.0	46.5	47.0	47.5	48.0	48.5	49.0	49.5
100	50.0	50.5	51.0	51.5	52.0	52.5	53.0	53.5	54.0	54.5

The foregoing tabulation is based on an alkaline solution of one-tenth normal, which would neutralize a sulphuric acid solution make up of 0.005 gram per cubic centimeter. The normality of the standard solution used would depend upon the acidity of the water tested. Greater accuracy would be obtained with water that is almost neutral, by using one-fiftieth normal, and some such more dilute standard than given in the table.

Table II gives the quantity of lime of 85 per cent activity that must be used for the average range of water consumption, to neutralize the acid contained therein.

TABLE II—QUANTITY OF COMMERCIAL LIME TO BE ADDED TO BOILER WATER PER HOUR

Pounds commercial lime* to be added to water per hour to neutralize acid therein.

Lb. Water Consumed per Hour	Parts of acid per 1,000,000 parts water, by chemical analysis— 5	10	15	20	25	30	35	40	45	50
100,000	0.41	0.83	1.24	1.65	2.06	2.47	2.88	3.30	3.71	4.12
110,000	0.45	0.91	1.36	1.82	2.27	2.72	3.17	3.63	4.08	4.51
120,000	0.49	0.99	1.48	1.99	2.48	2.97	3.46	3.96	4.45	4.92
130,000	0.54	1.07	1.61	2.14	2.68	3.22	3.75	4.28	4.82	5.36
140,000	0.58	1.15	1.73	2.31	2.89	3.47	4.04	4.61	5.19	5.77
150,000	0.62	1.24	1.86	2.47	3.09	3.71	4.33	4.94	5.56	6.18
160,000	0.66	1.32	1.98	2.64	3.30	3.96	4.62	5.28	5.94	6.59
170,000	0.70	1.40	2.10	2.80	3.50	4.20	4.90	5.40	6.30	7.00
180,000	0.74	1.48	2.22	2.96	3.71	4.45	5.19	5.92	6.67	7.42
190,000	0.78	1.56	2.35	3.13	3.92	4.70	5.48	6.25	7.04	7.83
200,000	0.82	1.65	2.47	3.29	4.12	4.94	5.77	6.59	7.42	8.24
210,000	0.86	1.73	2.59	3.46	4.33	5.19	6.06	6.92	7.79	8.66
220,000	0.90	1.82	2.73	3.64	4.54	5.44	6.35	7.25	8.16	9.07
230,000	0.95	1.89	2.84	3.79	4.74	5.69	6.63	7.58	8.52	9.48
240,000	0.99	1.97	2.96	3.95	4.95	5.94	6.92	7.91	8.89	9.89
250,000	1.03	2.05	3.08	4.12	5.16	6.19	7.21	8.24	9.26	10.30
260,000	1.07	2.13	3.20	4.30	5.37	6.44	7.50	8.57	9.63	10.71
270,000	1.11	2.22	3.34	4.45	5.57	6.67	7.79	8.80	10.01	11.12
280,000	1.15	2.30	3.46	4.62	5.78	6.92	8.08	9.13	10.38	11.45
290,000	1.19	2.39	3.58	4.78	5.98	7.16	8.36	9.46	10.75	11.95
300,000	1.24	2.47	3.71	4.94	6.18	7.42	8.65	9.89	11.12	12.36

* Above figures based upon 85 per cent active CaO in commercial lime.

By the use of such charts or tables, placed for ready reference, together with the flow chart showing the rate of water to the boilers, the quantity of lime to be added is readily obtainable. C. W. STEVENS.

New York City.

Making a Spongy Ferrous Casting Tight with Sal Ammoniac and Oxygen

We had a hurry-up order for a 12-in. valve to stand a hydrostatic test of 1,500 lb. Upon putting a valve under test, when 900 lb. pressure was reached, the fillet adjacent to the bolt flange at one end leaked little streams of spray, and great drops of water from the smaller interstices which formed, would unite and start little rivulets.

Electric welding a smooth cylindrical surface 42 in. long and 2 to 3 in. wide and leaving it smooth, seemed an impracticable and a precarious undertaking, and as the time to get it ready for shipment was short, the valve body, which had been machined, was filled with a saturated solution of sal ammoniac, and oxygen from a welding tank was permitted to flow through the solution till 1,500 lb. pressure was reached.

It was left over night or until the exuding liquid, judging from the taste, had permeated every pore of the steel and formed ammonia salts on the outer surface of the valve. When the level of the liquid was lowered till oxygen alone permeated the spongy parts, completely oxidizing its path, the casting was found bottle-tight, and it is today carrying 1,000 lb. pressure at 800 deg. superheat.

We had solidified many ferrous castings with sal ammoniac solutions and air, but this was our first attempt to use oxygen for both pressure and the oxidizing element, but as nearly all well equipped manufacturing plants have oxygen for welding purposes and seldom have air pressure high enough for testing high-pressure fittings, we believe the plan is commercial.

Orrville, Ohio. C. E. SARGEN.

COMMENTS *from* READERS

Keeping Power Equipment Clean

IN THE article, "Keeping Power Equipment Clean," by M. W. Wagner, in the Jan. 24 issue, attention is called to a combination of blower and vacuum cleaner. His suggestion that this device may be used as a vacuum cleaner to remove the dust when grinding commutators is a good one. As is well known, if this dust is allowed to collect in the windings and on the brush rigging, trouble due to insulation failures is almost sure to develop.

Before sandpapering a commutator I use a tallow candle on its surface. While the armature is revolving, the candle is drawn across the commutator, then when the sandpaper is applied, most of the copper dust will collect on the sandpaper. The paper will soon become coated with copper dust and it will be necessary to use a new piece. This method, to a degree, interferes with the cutting effectiveness of the sandpaper, but I prefer to have the copper dust on the sandpaper rather than in the machine.

Care should be exercised when using the candle not to get too much on the commutator at one time. Apply the candle at times when the sandpaper fails to collect the dust.

ROLLA O. MORRISON.

Chicago Heights, Ill.

* * * *

How to Get and Hold Good Men

ONE of the major problems that the engineer in charge must face in plants where the wages and working conditions are none too good is how to get and hold good men. Too often, the management's answer is that if the crew will not work for present wages, they'll get men who will, but that is no help to the engineer, who often sees men leave before they are thoroughly versed in their duties because other jobs offer more satisfactory terms. To keep them satisfied or make good workers out of the low-grade help that is found on these jobs is possible only by making the job more desirable, either with wage increases or privileges such as certain days off with pay.

A textile plant was handicapped with floating labor, and I could secure no co-operation from the management in the way of less hours or more money. Three men per shift fired several return-tubular boilers equipped with shaking grates, but they could not be induced to use the shaking lever, saying ash removal from the deep pit was hard work. The night shift worked 13 hours a night seven nights a week, and it was apparent that I must get better conditions for them. I took one man from the night shift, as the load on that shift was 40 per cent lighter than on the day shift, which met with sharp protest till I explained my intentions. This man, the least capable of the three, was assigned to the day shift and his duties then consisted removing all ashes and cleaning half the fires. No fixed hours were assigned him, but I got permission from the office to allow him to go home as soon as his task was finished. He began work at 5:30 a.m. in order to have half the fires cleaned when the day crew started. Then, as they had no ashes to remove on either shift, the firemen were more than willing to follow my suggestions about shaking down ash as fast as it accumulated. Formerly, the fires were cleaned immediately after 6 p.m. and again before the day crew came on, or twice in 24 hours, but owing to the large amount of ash and clinker shaken down, the cleaning was limited to once in 24 hours.

As hand cleaning involves a loss of capacity and efficiency, we naturally burned less coal afterward and started to cut out boilers, beginning with one boiler on the day shift and two on the night shift. When questioned, the firemen said the work was much easier and agreed to cutting out another boiler on each shift. I tried the experiment of using only one fireman on the night shift Saturday and Sunday nights, thus giving each night man one night off per week. This was so satisfactory that no one quit inside of a year, making a record for that plant at no money outlay, and the increase in efficiency was a net gain.

An engineer friend of mine complained of similar difficulties in his plant, with the addition of having a lazy fireman on the day shift whom he could not discharge, as the man was hired by the manager. His men worked seven days a week, twelve hours a day for $150 a month, and he had tried in vain to get a spare fireman, which would allow each one a day off each week. The manager would give the day off only at the firemen's expense, and everyone was dissatisfied, which means that the plant efficiency was none too good. I advised my friend to propose to the owners that he could save fully $300 a month by increased efficiency if they would spend the necessary $150 for a spare fireman, asking for one month trial period. All the men were willing to try to secure higher efficiency with the prospect of a day off a week, with the exception of the lazy fireman referred to, who took his day off by staying away at intervals, merely phoning in with an excuse of some kind for his absence.

As the boilers were not equipped with meters, there was no ready means of proving that his boilers were not steaming as fast as the others. One man was appointed head fireman with responsibility for the water level in all boilers. He suggested that a half-inch bypass be run around the feed valve on the two boilers that were suspected of not steaming up to capacity and closing the feed valve. By consulting a handbook, it was learned that at the excess pressure carried on the feed line, the bypass would admit just enough water to enable the boiler to steam at rating. As the others were doing 135 per cent most of the time, we knew that as soon as the two boilers in question approached that rating the water level would drop and the water tender would have to open the main feed valve slightly. But as long as the bypass could feed

enough water, it was plain that the fireman was loafing. With this check upon his activities, the fireman met with sharp comments from his mates whenever the water climbed high enough to force them to close the main feed valve, as they then had to do 35 per cent more than he. Upon seeing that he could not longer bluff his way along, the fireman made a wonderful improvement in his firing, since he had to keep his fires free from holes to maintain the same rating as the others. The increased efficiency amounts to more than twice the pay of the spare fireman, and good men can be secured and stay longer than formerly.

From the experience gained in these two and other plants, I have come to the conclusion that good working conditions will attract and hold good men and the final result is increased efficiency. It is all very well for managements to say that the market is full of experienced power-plant help, but do they know the extent of the loss when a capable man leaves to go to a plant giving shorter hours or more pay? Nine times out of ten he must be replaced by a man who has not the ability to get into the more desirable plants, and after you have spent time and money making a fairly efficient workman of him, he goes out to seek the improved conditions that his increased abiliity warrants. C. O. ALLEN.

Chicopee Falls, Mass.

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Popular Engineering

ONCE upon a time in the history of industrial development, if a man made a better mouse trap, though he built his house in the woods, the world would wear a beaten path to his door. That stage of industrial com petition, or rather lack of it, is definitely in the past of forgotten methods. Today, we not only have the popular appeal of manufacturers of similar products to the public in a language they can understand, but we have whole industries uniting to set forth their merits directly to the public in competition with other whole industries, as witness the appeal of the ice distributors as against electrical refrigerators for the home.

Yet engineering, as a profession, still side-steps the public to a great extent, as not being capable of understanding such highly professional and technical matters as the details of engineering development. True, these details often do reach the public, but not from the hands of the engineer, who is best fitted to present them; but, rather, from the pens or mouths of those who are interested in the development of the idea from a promotion, sales or financial viewpoint. With his superior wisdom the engineer is often prone to sit back and criticize those who are endeavoring to do his work without the proper tools of an engineering background, and make much of the technical errors that may be so introduced, wholly unconscious of the fact that the greater fault is his, in letting slide by his opportunity to present properly the engineering aspect to the public in a manner they can both understand and appreciate.

It is not that engineers are secretive; they discuss these matters among themselves in their own societies and publications. But they feel it would be unethical to present the "dope" in anything but a highly technical manner. To say that a given quantity is a direct function of another and an inverse function of a second is too simple; much better to say $\infty : K \cdot \frac{\gamma}{b}$ is the altitude of many engineers. But the paramount fact to face, is the big question as to whether it is better to limit the number of intelligent readers to a minimum professional audience, or to expand it to a maximum popular group.

It is only by interesting the vast army of "men in the street" that the engineer can hope to attain his rightful place and reward in the progress of industrial development. It is a fact that the engineer is vastly underpaid in terms of his contribution to the success of the enterprises he is interested in, but a great part of this is undoubtedly due to the fact that he has not properly taken the public into his confidence. To do this is not such a vast undertaking; it merely means that when he writes, he should present his story in ordinary language and avoid the purely technical presentation; and, when he talks, he should seek a general audience rather than a purely professional one. When engineers as a whole do this, it must follow that the profession will receive a greater rather than a lesser recognition, which will inevitably be reflected in the rewards they reap for their industry. J. F. HARDECKER.

Philadelphia, Pa.

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Why Boilers Explode

THE article in the Jan. 17 issue entitled "A Boiler Inspector Has an Exciting Experience," is one that should never have been written. Fancy a boiler supposed to run at 100 lb. pressure rising to more than 250 lb., straining the boiler and narrowly averting serious consequences. This was caused by screwing down the adjusting nut on the safety valve and then not releasing it.

Whoever screwed down the adjusting nut ought to have had some slight idea how much to give it. Screwing it down so much more than was necessary betrays gross carelessness or downright ignorance, such as cannot be excused in the chief engineer of a plant or in a boiler inspector.

I fully agree with Mr. Kugmann in using clamps during the hydrostatic test on a boiler. The safety valves could even be removed and a blank flange used, as occasionally safety valves leak during such a test.

Would it not be a good idea to have a brass ring or washer under the adjusting nut so that it would be impossible to screw the nut farther down than necessary for the allowable working pressure on the boiler? Such a ring is compulsory in British Columbia.

Was the boiler strained? I wonder. In all probability it had a factor of safety at 100 lb. pressure, of 5 at least. Then the plate percentage may have been about 80 per cent.

The A.S.M.E. gives $\frac{T_s \times t \times E}{R \times F_s}$ = maximum allowable working pressure in pounds per square inch, where

T_s = ultimate tensile strength of shell plate;
t = plate thickness;
E = efficiency of longitudinal joint;
R = inside radius of shell;
F_s = factor of safety.

The elastic limit is usually half T_s, so I would like to hear the opinion of others on this boiler. If the elastic limit be not exceeded, is the boiler damaged?

Toronto, Canada. J. S. SHORT.

The Mechanical Equivalent of the Mean Heat Unit

IN THE Feb. 21 issue the answer to Ques. 5 in "What Do You Know?" states that "the mechanical equivalent of heat is 777.54 ft.-lb., which is generally taken as 778." In the report on "Progress in Steam Research at the Bureau of Standards," presented at the annual A.S.M.E. meeting in December, 1927, the value of the mechanical equivalent of the mean calorie is given as 4.189 Joules, and that of the B.t.u. as 778.6 ft.-lb. This value appears to be the latest and possibly the most probable correct determination of this important constant, it being based on the latest and best laboratory technique.

State College, Pa. A. J. NICHOLAS.

* * * *

Using Hydrochloric Acid In Boilers

IN THE Dec. 27, 1927, issue Ques. 8 in the "What Do You Know" column asked, "How can you prevent boiler fractures due to caustic embrittlement?" The answer given on page 1028 was as follows: "Add hydrochloric or sulphuric acid until boiler water is either neutral or slightly acid."

From a purely chemical point of view the answer is correct, but I suggest that if it were put into practice much more serious trouble than that due to caustic embrittlement would result.

Water containing caustic soda generally contains a certain amount of carbonate of soda, especially as it comes from the softener. If acid is added to the water to make it neutral, even if it be only to phenolphthalein, there will be bicarbonate of soda in the water. This, on going forward to the boilers, plus oxygen, may cause corrosion due to liberation of carbon dioxide.

To advise that the water be made slightly acid with a mineral acid such as hydrochloric or sulphuric acid is a most dangerous recommendation, as such water would be highly corrosive and would attack not only the boiler, but the feed-pipe lines and auxiliaries. Steam would also become contaminated with acid gases, which would affect the turbines.

Each case of caustic embrittlement requires the most careful consideration by a chemical engineer who has had considerable experience in feed-water treatment. Where a zeolite plant is being used and the water contains temporary hardness, it might be necessary to cut that plant out as regards the boiler. With a lime-soda plant every effort must be made to keep the caustic alkalinity of the water in the boilers as low as possible, consistent with satisfactory results, while at the same time bearing in mind the question of density and losses due to blowdown. In some cases the use of an alternative feed-water supply, if available, should receive consideration.

Finally, if the difficulty cannot be overcome by the methods given herein, it may be necessary to treat the feed water in an entirely different manner to that in use.

GEORGE S. IRVING, MANAGER,
Feed Water Specialties Company.

Liverpool, England.

[It is quite a general practice to use sulphuric acid as outlined in the answer questioned by the correspondent, and hydrochloric acid is used by some other plants.—Editor of "What Do You Know?"]

Answers to What Do You Know

The questions are on page 413

Ans. 1—If the engine is to run at the same speed as before and if the governor mechanism could not be changed, the eccentric would give the same travel to the valve as before. Since the steam pressure is raised, this cutoff would cause the engine to have too great a m.e.p. and the engine would speed up. As this is barred, it will be necessary to reduce the total cylinder mean pressure by inserting a liner.

Ans. 2—The maintenance after three or four years' operation will generally range from one to two per cent of the initial engine cost.

Ans. 3—The three-sheave block should be attached to the weight and the other block to the deadman or other anchor. This is for the reason that there is more pull at the three-sheave block due to the pull of the man.

Ans. 4—If the car is being accelerated upward, the spring scale will register more owing to the necessity of accelerating the weight.

Ans. 5—As the water is 200 ft. deep, the pressure exerted on each square inch of projected area is $200 \times 0.433 = 86.6$ lb. gage or 101.3 lb. abs. The projected area is 2,500 sq.ft., making the total pressure on the top of the vessel 18,234 tons. The vessel has a dead weight of 1,000 tons which must be added, making a total of 19,234 tons stress on the lifting apparatus until the vessel is raised sufficiently to permit water to get under the boat; as soon as this occurs, the stress reduces to the weight of the boat, or 1,000 tons.

Ans. 6—The frequency of the rotor current may be obtained by the formula $B = \frac{PS}{120} + f$, where F is the frequency of the rotor current, P the number of poles in the stator winding S the rotor speed in revolutions per minute and f the frequency of the line current supplied to the stator winding. In this problem $F = \frac{8 \times 1{,}800}{120} + 60 = 180$ cycles per second. Machines of this type are in common use as frequency changers for increasing the frequency of alternating current of high-speed motors for driving certain classes of grinders.

Ans. 7—The pump end is slightly air bound and the pump moves at a high speed against the negligible resistance until the pressure has been raised to about the discharge pressure.

Ans. 8—The factor of evaporation is the ratio of the heat required to generate a pound of steam under actual conditions to that required to generate one pound of water at 212 deg. F. into steam at 212 deg. F.

Ans. 9—The first gas-producer engine was built by John Barber in 1791.

Ans. 10—Atmospheric air always contains a certain amount of water vapor mixed in it. The pressure of the vapor cannot exceed the saturation pressure corresponding to the temperature of the atmosphere. Generally, the vapor is in a superheated state and the pressure is less that the saturation pressure. The relative humidity of the air at any time is the percentage of moisture contained in it as compared with the amount it is capable of holding at the same temperature. The degree of saturation or relative humidity of the air is easily determined by the use of the dry- and wet-bulb thermometer.

New and Improved EQUIPMENT

Keystone Pneumatic Centralized Greasing Station

THE Keyst ne Lubricating Company, Philadelphia, Pa., has recently extended its line of safety lubricating appliances for use in the power plant and industrial plant fields by the addition of the central pneumatic lubricating unit illustrated.

The unit is designed for feeding grease through one or more header lines with connecting leads to practically any number of bearings and at varying distances from the unit up to a total distance of 300 ft. It is intended to replace the manually operated unit, which has been manufactured for some years by this company, especially where an exceptionally large number of bearings are to be fed from one central point.

The arrangement of the connection used with the new unit, shown in Fig. 2,

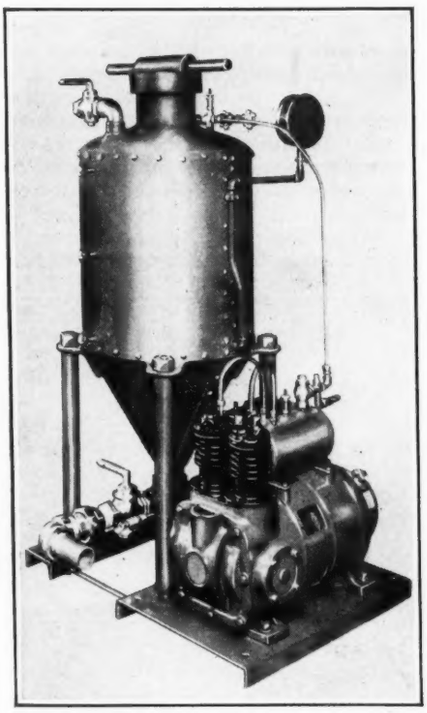


Fig. 1—Pneumatic pressure unit with motor-driven air compressor

and the pressure reduction valve and automatic converter cup shown in Fig. 3 are essentially the same as used with the manually operated unit.

The pressure unit shown in Fig. 1 consists of a conical-base grease tank and an automatically controlled motor-driven air compressor mounted on a common base. The compressor is regulated to maintain the pressure between the limits of 170 and 210 pounds.

The tank is made from $\frac{3}{16}$-in. steel plates, with the seams riveted and electric welded. The discharge is connected at the bottom of the conical base, and the tank will discharge from 88 to 100 per cent of its contents, depending upon the density of the grease used. Three telltale pet-cocks are provided on the side of the tank for indicating the various grease levels. A 1-in. connection is provided at the top of the tank to permit filling the tank by pumping the grease directly into it and a large opening at the top for filling with grease that will not permit of pumping.

Referring to the piping diagram, Fig. 2, the unit is placed at some convenient position and piped to the numerous bearings with the converter cups and the necessary stopcocks, check valves and a regulating valve at each bearing.

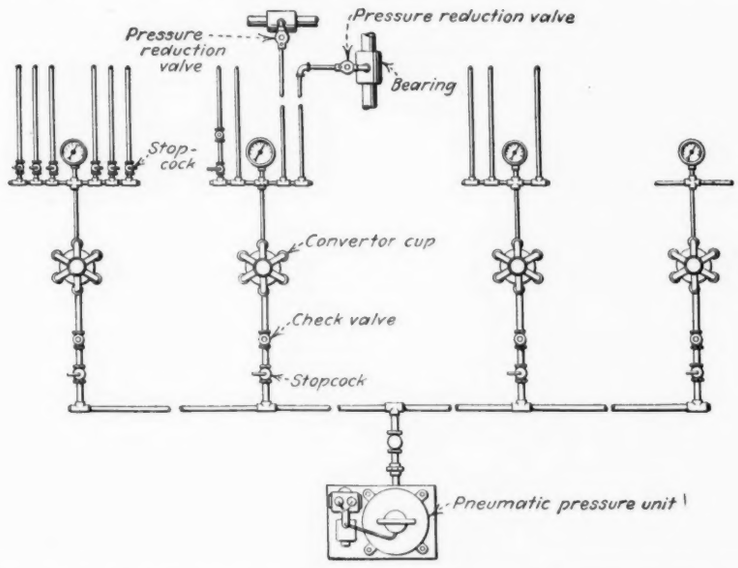


Fig. 2—Typical piping diagram showing arrangement of pressure unit and accessories for regulating the feed to the bearings

The converter cup is designed to maintain a pressure on a section of a system feeding a number of bearings, and it is generally placed a considerable distance from the main pressure unit and adjacent to the machine or group of bearings being lubricated. The cup is charged with grease until the

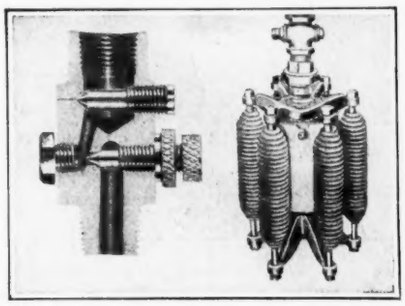


Fig. 3—Pressure reduction valves and automatic converter cup

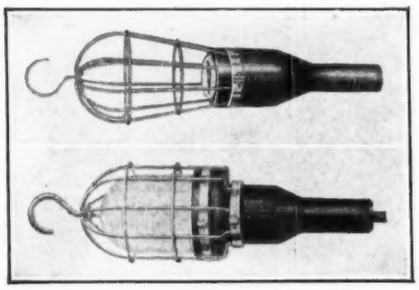
springs are extended, giving a pressure of about 40 lb. on the lead lines to the bearings. When the pressure has receded to 10 lb. as indicated by the gage, it is again charged and the pressure raised to the high point. The gage reading is in the ratio of 5 to 1; 40 lb. on gage equals 200 lb. actual pressure.

The pressure reduction valve shown in Fig. 3 is inserted in the lead line at each bearing and is adjusted to give proper feed of grease for the type of bearing being lubricated.

The lubricator units are made in two sizes, with a grease capacity of 150 and 450 lb. respectively.

Woodhead "Protex" and "Vaprotex" Extension Lamps

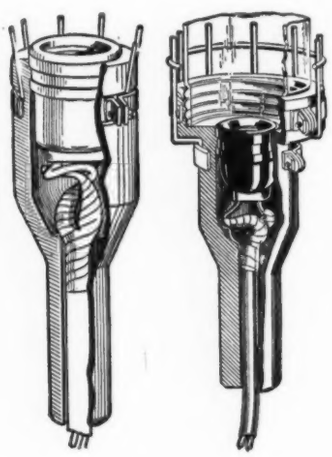
WITH a view to reducing the fire and electrical hazard in connection with use of extension lamps, the Daniel Woodhead Company, Chicago, Ill., has introduced the extension lamps illustrated, which have insulated handles



Figs. 1 and 2—Protex and Vaprotex lamp

that extend well over the socket and lamp terminals.

The lamp shown assembled in Fig. 1 and in section in Fig. 3 is known as the "Protex." The handle is made of a high-grade rubber compound and is designed to cover the lamp socket and terminal, with proper spacing allowed for joints. A seat is provided inside the handle to act as a cord grip, thus removing all strain from the socket and terminals. As the socket is made of



***Figs.** 3 and 4—Section through socket, showing construction and cord grip in handle*

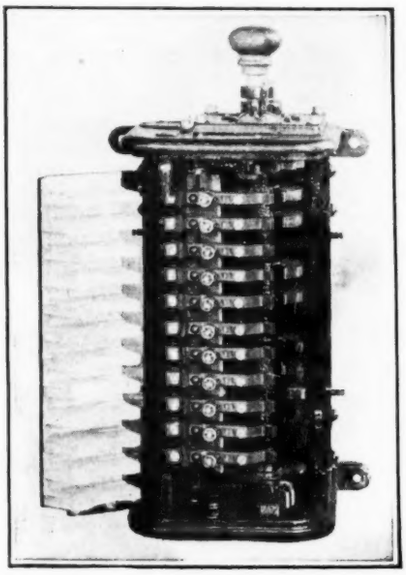
pliant rubber, its resiliency tends to protect the lamp bulb against jars or shocks.

The lamp shown in Figs. 2 and 4, know as the "Vaprotex," is designed to prevent combustion and explosion where gas and dust hazards exist. The handle and socket holder are in one unit, molded of a rubber compound and threaded to hold the lamp. The dust and vaporproof globe is of heat-resistive glass, held in place by a guard of heavy wire cadmium plated to prevent rusting.

New Drum Switches for A.-C. Motors

THREE new drum switches, of the type shown in the figure, are announced by the General Electric Company for use with squirrel-cage and slip-ring motors. They have been designed particularly for the control of small cranes, hoists, machine tools, etc., but can be applied on any work where a small and inexpensive drum switch is desired for the control for the types of motor mentioned.

One of these switches is a primary-resistance drum type for squirrel-cage



Switch cover removed

motors, providing four points forward and four points reverse. It is suitable for motors that do not have an overhauling load; that is, on hoists this switch can be used where worm gearing or automatic mechanical load brakes are used.

A second type is a primary-resistance switch for squirrel-cage motors, providing four points forward and one point reverse. This switch is suitable for use where there is an overhauling load, such as on hoists, where a worm gear or automatic mechanical load brake is not used. In such a case one point reverse is provided so that the motor will exert sufficient torque to prevent excessive motor speeds when overhauled by the load.

A third switch is a primary- and secondary-reversing type for slip-ring motors, providing five points forward and five points reverse. It is suitable for starting duty or speed-regulating duty and for use with 220-, 440- and 550-volt motors, rated at fifteen horsepower and less, where a five-point switch would be chosen.

All three switches have the same frames, but the cylinder developments are different. Horizontal handle, vertical handle, and rope wheel and spring return attachment are interchangeable.

Improved Reeves Variable Speed Transmission

THE adoption of a double-block center-pull V-belt and the redesigning of the frame to make the unit more compact are among the improvements recently made to the variable speed transmission manufactured by

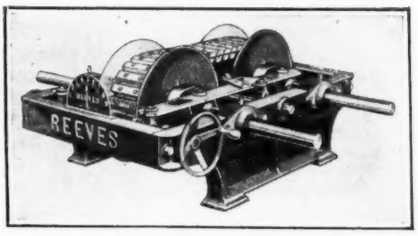


Fig. 1—Improved unit assembly

the Reeves Pulley Company, Columbus, Ind.

With the double-block V-belt the line of pull is at the center and the load is evenly distributed above and below. Also with the increased contact area the belt can be run with less tension and consequently less load on the bearings. Tests indicate that this belt will transmit about 25 per cent more power than the single blocks belt formerly used.

The over-all length and width of the frame have been reduced making it

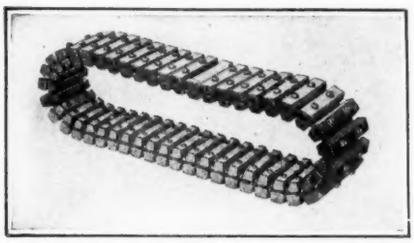


Fig. 2—Double-block V-belt

more compact. The reduction in width has been accomplished by mounting the bearing housing inside the recesses of the frame sides. This brings the bearing housings closer together on the shaft. The force-feed system of lubrication has been changed to give a better distribution of the lubricant to each bearing.

Standard equipment on the improved unit includes a speed indicator which is mounted on the frame to show the approximate speed at which the transmission is running.

Effect of Steam Reheating and Stage Feed Water Heating on Turbine Development*

By Edwin H. Brown

DEVELOPMENT of the steam turbine for service as a power generating unit in the central station type of power house proceeded for practically twenty years, 1900 to 1920, along the lines that involved only the expansion of steam between the station steam header and the condenser. During the last eight years the use of extracted steam from between turbine stages for heating feed water has had a marked effect on the turbine, and the more recent application of the reheat cycle has likewise added another factor to the considerations entering into turbine development and practice.

Extraction feed-water heating probably has met the least resistance of any departure from precedent in turbine design and construction. As the method of making the main steam pipe and condenser connections has been one of the most important and rigidly specified mechanical details of the turbine, the proposal to add more connections, at the time extraction feed heating was first being revived, was regarded with some apprehension, but results have been satisfactory and no doubt have been of value in considering the reheat problem.

Extraction of interstage steam has altered the design of the turbine cylinder more than is apparent by casual inspection, particularly in the low-pressure sections where the greatest volume of steam is extracted, but where the temperatures and temperature changes are the smallest and where the interstage clearances between the moving and stationary parts are large. Although the cylinder has become a more complicated structure, this change in mechanical design has not affected the reliability of the machine.

From interstage extraction the heat consumption gain, both theoretical and practical, has been appreciable from the lowest to the highest steam pressure and has found application over the full range of standard turbine sizes. It benefits the high-pressure turbine particularly, because it increases the volume of steam flowing through the high-pressure stages, where, in all types of steam turbines, the prevention of leakage between stages is a problem that is solved only by relatively close packing clearances. This can be visualized best by considering that the steam, which otherwise would be supplied to auxiliary and house turbines, will be passed through the higher-pressure stages of the main turbine having an extraction system, with the result that the percentage leakage loss in these stages will be reduced.

Considerations given by the turbine builder to the problems that have arisen from the application of reheat and regenerative cycles, with comment on boiler reheating vs. steam reheating.

The large steam turbine has been improved by extraction, because, as usually applied, it reduces by 15 to 20 per cent the volume of steam to be utilized by the final stages, where it has been most difficult to provide sufficient exhaust nozzle and blade or bucket area to take full advantage of the vacuum available. These exhaust or leaving losses increase with the square of the volume of steam exhausted to the condenser, so that by reducing this volume, extraction has contributed to the increase in size of single generator turbine units which has been such a marked development in recent years.

For modern extraction heating, the design of the turbine has been carried to the point where the machine is no longer proportioned for straight condensing operation and then provided with extraction belts and nozzles. Generally, it is proportioned for the different amounts of steam flowing through it, and this step has resulted in the economy of the units being estimated directly for extraction operation, a most desirable condition if full advantage is to be realized from the regenerative cycle.

Extraction of steam from those stages in which the steam is moist has had a beneficial effect by reducing the amount or proportion of power developed in the moist-steam range, where the moisture seriously affects the stage efficiency. This also is one of the chief advantages for all stages of extraction so far as the turbine alone is concerned.

As the application of the reheat cycle to the modern steam turbine has been a development that has accompanied the increase in steam pressures beyond 400 lb. gage, it has not as yet left its mark on the general field of steam-turbine practice. For steam pressures above 1,000 lb. gage, reheating of the steam, according to present practice, would be essential as a means for reducing the large amount of work that otherwise would be done by moist steam, and for insuring protection against excessive erosion in the final stages where blade or bucket velocity in the large turbine is high. Reheating for these higher pressures is obviously necessary, therefore, for both mechanical and economical reasons.

For lower steam pressures in the 600-lb. range such specific conclusions cannot be drawn. The turbine performance is benefited appreciably, from 1½ to 6 per cent and more, depending upon the degree of reheat. The moisture in the final stages is reduced sufficiently to make erosion of blading or buckets a minor consideration. These are outstanding advantages. On the other hand, there is the question of the influence of reheat on the arrangement of the turbine, whether single- or multi-cylinder, and the experience that is being had in improving the erosion re-

* Paper presented before Mid-West Power Conference, Chicago, Feb. 17, 1928.

sistance of high-velocity blades operating with moist steam.

To the highest steam pressures with reheat, the turbine has been applied as a multi-cylinder unit, but in the 600-lb. field single-cylinder as well as multi-cylinder machines, are used. The multi-cylinder arrangement confines the high-temperature sections to the short lengths of each cylinder making up the machine, a simple and reliable construction in many respects and one that experience indicates will be largely free from operating difficulties that originate in differential expansion. It has the disadvantage, however, when the cylinder is divided to accommodate reheat, of requiring additional high-pressure shaft glands or packing, a source of loss in efficiency and of repair or maintenance. Also, the multi-cylinder arrangement is the more costly construction.

Single-cylinder construction for reheat involves a more complicated cylinder with large extraction belts or passages and large extraction pipe connections. The experience with the developments resulting from the piping connections made to the cylinder, in applying the regenerative extraction cycle to the turbine, have shown that much can be done without interfering with the operating reliability. However, with reheat connections of large size into the higher-pressure stages, where the clearances are small, a more difficult problem is presented to the turbine builder, and the difficulty is enhanced by the extension of the high-temperature section of the cylinder in the small clearance region.

The plan of reheating steam by steam reheaters has not affected the turbine problem for the highest-pressure applications, where it has been combined with boiler reheat for regulation purposes. But when applied alone in the 600-lb. pressure range, the effect has been to reduce the gain in economy to 3 per cent or less, depending upon the proposed arrangement, because of the lesser amount of heat added and the lower final reheat steam temperature. The reduced gain in economy, however, is not accompanied by a corresponding reduction in the degree of blade erosion protection.

Estimates have shown that steam reheat can be applied at pressures as low as atmospheric with a small improvement in turbine efficiency and with a great reduction in moisture in the final stages of the machine. This plan contemplates a low reheat temperature of not over 300 deg. F. and is most interesting in other respects.

An appreciable part of all reheat gain in a turbine results from improved turbine efficiency in those stages that otherwise would work with moist steam. The lower the reheat pressure, the more important this factor becomes, until at atmospheric reheat pressure, it is the most important item, together with the actual efficiency of the turbine itself, that influences to a marked extent the amount of heat to be absorbed from the reheater.

Feed-Water Treatment Retards

Boiler-Plate Embrittlement

By S. W. Parr* and Frederick G. Straub†

Presented at the Mid-West Power Conference

Sodium phosphate and tannate in relatively small quantities have been found by the authors to retard the embrittling action of caustic soda. Their use, it is thought, will avoid some of the present difficulties of maintaining a correct sulphate ratio. The treatment of feed water with these reagents is, however, still in the laboratory stage of development.

Within recent years a phenomenon of more or less frequent occurrence has become recognized, to which the term "the embrittlement of boiler plate" has been applied. Because of the relatively infrequent occurrence of this difficulty and the more or less obscure causes that bring it about, the fact of embrittlement has been largely in question. However, both the evidence of its presence and the conditions which promote it are matters of paramount importance at the present time, because within recent years an increased number of boiler failures chargeable to embrittlement have occurred.

Recent Instances of Embrittlement

During the interval between June, 1926, and September, 1927, ten new instances of embrittled boilers involving some 25 different boilers were brought to the attention of the investigators. A rough compilation as to the cost of replacing or repairing these boilers showed that at least $150,000 was involved. In addition to cost one must consider the fact that in many plants the cracking had progressed so far that the lives of the operators were endangered.

In all instances the boiler feed water did not meet the A.S.M.E. recommendations as to sodium-carbonate sodium-sulphate ratio. The sulphates were low in all cases.

To determine what is producing embrittlement in steam boilers, it is essential that all contributing factors be given equal consideration. The four following factors have been carefully considered in each case investigated in trying to explain the cause of these failures: (a) Material, (b) workmanship, (c) operation, (d) feed water.

The first three, material, workmanship and operation, may have a large influence on the cause of embrittlement, yet they have never been found to be the same through all embrittled boilers. The material and workmanship in one embrittled boiler may be bad, while in the next it may be excellent. Similarly, a boiler operated carefully at low rating may crack, while another may crack after heavy service.

On examining the mass of data collected from embrittled boilers, one could not help seeing that the type of feed water used in embrittled boilers was apparently the only common factor. When the feed water was analyzed, it disclosed the fact that sodium carbonate was always present while the sulphates were much lower. The boiler waters showed the presence of high alkalinity with a corresponding small sulphate content.

Boiler feed water can be considered roughly under two heads, carbonate and sulphate. The former have the carbonates of magnesium or calcium in excess and have only a small amount of the corresponding sulphates. This has commonly been termed temporary

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hardness since it decreases on heating. The sulphates of calcium and magnesium are changed but little on heating and have been termed permanent hardness. In some natural waters in the United States sodium bicarbonate is present in appreciable amounts and almost invariably the sulphates are low in respect to the sodium bicarbonate. On heating the boiler, the sodium bicarbonate breaks down to give the carbonate, which in turn decomposes to give sodium hydroxide and carbon dioxide.

The amount of the decomposition of the carbonate depends on the temperature or steam pressure and the partial pressure of the carbon dioxide. In a boiler the steam carries away the carbon dioxide favoring the formation of the hydrate. Boilers have been found where over 90 per cent of the sodium carbonate has gone over to the sodium hydroxide.

One thinks at once—all boilers have sodium hydroxide in them, since soda ash is a common boiler compound. This is so, yet the amounts are no place near those encountered in embrittled boilers and, furthermore, the sulphates are present in large amounts.

Laboratory Investigation

The fact that the cracks in embrittled steel were intercrystalline suggested a means of attack in the laboratory. The occurrence of intercrystalline cracking in boiler plate had never been reported under conditions which simulated boiler operation. A few isolated instances where selective corrosion had attacked the grain boundaries of steel had been reported, but the conditions were such as could not be encountered in operation. Boiler plate subjected to high stresses, impact tests, fatigue tests, corrosion fatigue, etc., are almost invariably transcrystalline and follow the line of maximum stress. These cracks may pass along one or two grain boundaries, but in general are transcrystalline.

The embrittled boiler plates are in general cracked intercrystalline, and it is the exception when the cracks cut across a grain. This has been used as a means of detecting embrittlement cracks. Since this distinct difference could be found between normal failures and embrittlement failures, attempts were made early in the investigation to reproduce this type of cracking at will under known test conditions. The attempts met with success, and a tool was immediately placed at the disposal of the investigation to study the conditions of its occurrence and methods to stop it.

A brief summary of the results obtained from the laboratory tests conducted toward the explanation of this intercrystalline cracking is as follows:

1. Two conditions must be present simultaneously to cause embrittlement of mild steel in the laboratory test containers; first, the actual stress must be above the region of the yield point of the metal; and second, the concentration of solution must be above 75 grams per liter (about 4,000 grains per gallon).

2. Solutions of salts occurring in boiler waters other than sodium hydroxide did not affect the stressed metal.

3. Pure iron cracked as well as regular boiler plate.

4. Cold work or heat treatment did not accelerate nor retard embrittlement cracking.

5. Steel subjected to a high intensity of load for five years failed to crack; but the same steel under the same load cracked in less than three days when brought into contact with caustic solution.

6. Increased steam pressure accelerates the cracking.

Inhibiting of Embrittlement

When the attention of the earlier investigators was first called to the fact that sodium hydroxide might be a contributing factor in the embrittling of boilers, attempts were made to stop the formation of the hydroxide in the boiler. The addition of organic matter was tried with no marked success, since it did not retard the decomposition of the carbonate to any extent. Early in 1914 attempts were made at the University of Illinois power plant to lower the sodium carbonate content in the feed water by adding magnesium sulphate. This formed sodium sulphate and decreased the sodium carbonate content. Later, this was changed to a sulphuric-acid treatment. The regular treatment was made and then sufficient sulphuric acid added to neutralize about two-thirds of the sodium carbonate in the water. Before this system of treatment was adopted, difficulty had been experienced on all boilers, and since adding this treatment no further difficulty of this nature has been encountered.

A recent thorough examination of these boilers involving removal of rivets and a thorough examination of the rivet holes showed that after ten years' operation on this treated water the boilers were free from any indications of embrittlement. Within recent years the tendency toward keeping a definite amount of sodium sulphate in all boilers using sodium carbonate waters has become popular with large power plant operators, so that at present over twenty plants are using this means to inhibit embrittlement. The method of increase of sulphate is accomplished by various means, some using acid while others use aluminum sulphate, iron sulphate, etc. Some plants that encountered embrittlement changed to other sources of supply free from carbonate with the elimination of the difficulty.

The use of sulphate treatment is very limited, and since the occurrence of embrittlement is apparently on the increase, other methods of stopping it have been diligently sought. The use of a sulphate ratio on waters low in calcium and magnesium is possible, but when these salts are present it becomes practically impossible to keep the recommended ratios at the higher pressures. Furthermore, the use of acid is to be recommended only when the direct supervision of a man conversant with the use of chemicals is available. An overdose of this medicine may result in more trouble than the original disease, consequently the operators and men responsible for large power units hesitate to use acid under average conditions of operation.

When evaporators are used on alkaline water, it becomes difficult to get a water free from sodium carbonate. The acid treatment of these waters is impossible. The addition of sodium sulphate defeats the purposes of evaporation, consequently a new inhibitant is sought for this type of water.

The inhibitant must be non-corrosive and stop embrittlement when used in relatively small amounts; overtreatment must cause no trouble, require but a small amount of chemical control and be inexpensive. Work has been conducted with good success toward the finding of inhibitants to meet these conditions.

Methods of treatment for various types of waters and conditions of boiler operation are being investigated by the authors, having special reference to the development of further inhibitive conditions or reagents with the prospect of avoiding some of the present difficulties attending the maintenance of the sulphate ratio and also greatly simplifying the procedure for the prevention of this serious menace.

Sodium phosphate is one of the reagents that the authors have tested to determine its qualities as an inhibitant of embrittlement. The results indicate that comparatively small amounts of this inhibitive salt will retard the embrittling action of sodium hydroxide. Thus, as low as three grams per liter of sodium phosphate ($Na_3PO_4 .12H_2O$) prevented embrittlement in the presence of approximately 300 grams per liter of sodium hydroxide at a steam pressure of 500 lb. When sodium sulphate was used at this pressure, it was necessary to have five times as much sodium sulphate as sodium hydroxide. The phosphate appears to be effective as an inhibitant and requires only one part of sodium phosphate to 100 parts of sodium hydroxide—less than 1/500 as much as the sodium sulphate. Similar figures can be shown for the use of tannate. Tests are being conducted with other salts as possible inhibiting agents.

The possibility of the use of these new inhibitants is at once evident, but their application in boiler feed-water treatment should not be tried until more laboratory work is in evidence and more data can be collected from plant operation. It should be realized that these figures represent data collected from the accelerated laboratory tests and are not directly applicable to operating conditions.

The Strength of Steel at Elevated Temperatures With Particular Reference to Safety Factors*

By T. McLean Jasper†

IN A DISCUSSION of the question involving safety in design and the strength of metal in service under elevated temperature conditions, the matter must of necessity be considered from two different angles. The one deals with the nature of the distribution of stresses in a particular design and considers a constructive change of inadequate safety measures, and the other considers the careful production of facts concerning the strength of the metal at elevated temperatures, which is used in the equipment which has been designed.

In other words, a poorly designed structure using very strong metal may not be as safe as a well balanced design using a weaker metal, and unless the strength values of the steel under appropriate testing conditions are obtained, the factor of safety when assuming a given stress is not what it is supposed to be.

Factors of safety have often been calculated on pressure containers to be used at elevated temperatures by applying the short-time laboratory test for strength of the metal, together with the ordinary cylinder formula,

$$S = \frac{PD}{2t}$$

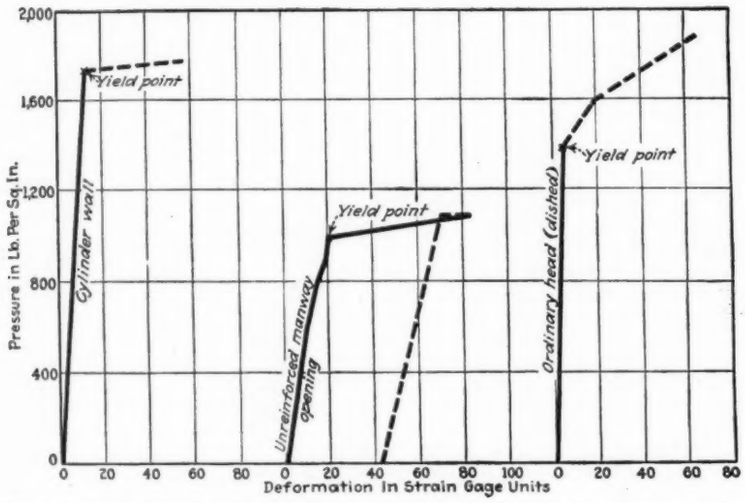

Fig. 1. Strain value in main cylinder, at unreinforced manways and ordinary dished head

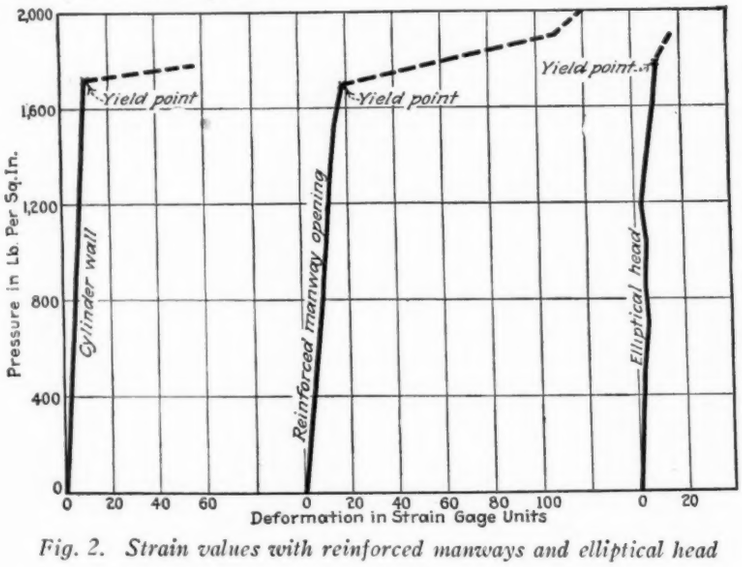

Fig. 2. Strain values with reinforced manways and elliptical head

without considering the weakening effect due to lack of reinforcing at openings or the weakening effect due to the shape of the heads or sometimes the weakening effect of the joint if it is not equal in strength to the metal that is joined.

If a pressure container is joined together in such a manner that localized stiffening occurs at the joints, then intensified stresses may occur adjacent to the joint and cause the pressure container to be weaker than anticipated. If the joint has an efficiency less than 100 per cent, the intensification of stresses adjacent to it may be less than that occurring at the joint. If, however, a change of shape occurs near the joint, such, for instance, as in the small radius of a dished head in which the stiffening action of the joint is added to the stress intensification due to the shape of the head, then this condition of stress intensification may cause rupture at a much lower stress than that anticipated. This applies in a greater degree when considering thick-walled pressure containers.

It is the general impression among designing engineers that the strength of steel at elevated temperatures for continuous operation is considerably more than it really is. This is brought about by the fact that the data on which the values are based are obtained from

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short-time tests rather than those represented by continuous operation. It is not generally known at this time that at elevated temperatures the short-time test values of a steel vary materially from the long-time test values. Especially is this true when the temperatures considered are above 600 deg. F. At 900 deg. F. the short-time strength of low-carbon boiler steel, in which the carbon varies

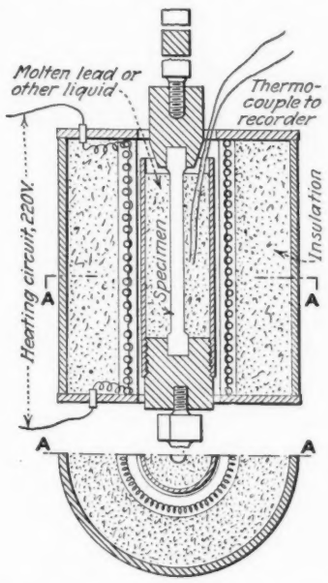


Fig. 3. Method of heating test specimen

from 0.08 to 0.12 per cent is 32,500 lb. per sq.in., while the long-time strength of this material is 15,000 lb. per sq.in. For 0.20 to 0.30 per cent carbon steel the values are 35,300 and 18,000 lb. per sq.in. respectively. The average strengths of these two steels at ordinary temperatures are 49,000 and 59,000 lb. per sq.in. respectively.

When such values are appropriately applied to the design of pressure containers which are to be used continuously over a long period of time, it becomes obvious that the long-time test result is the only safe value to use. At ordinary temperatures the long- and short-time test values for steel are practically the same.

Determination of the Value of Design

The ordinary steel used in the construction of pressure containers has a yield point that is very pronounced. The diagrams were made from a pressure container having a two-inch wall thickness, a diameter of 6 ft., length of 40 ft. and a dished head. These diagrams show the relation between test pressures and strains. The strains are measured by using either a four-inch or a two-inch Berry strain gage over an appropriate gage length.

In Fig. 1 has been plotted the relations between test pressures and strains which were obtained at three different points in the pressure container. In the first curve is plotted this relation for the cylinder at a point sufficiently far removed from any discontinuity, due to design or method of fabrication, to test out the simple cylinder formula used, that is

$$S = \frac{P D}{2 t}$$

in which S is stress in the material, P the test pressure, D the diameter of the pressure container, and t the thickness of the wall.

The pressure in the cylinder at the indicated yield point was 1,740 lb. per sq.in. Substituting this value in the given cylinder formula for the vessel tested, the yield point value would be 31,300 lb. per sq.in. The average test results for the different pieces of steel used in the pressure container showed a yield point value slightly below 32,000 lb. per sq.in. It will be seen that the formula used is correct because the yield point given by this steel under ordinary tensile tests, is approximately the same value as the yield point found when the pressure is used in the formula given above.

The second curve which is for an unreinforced opening shows that the yielding occurred at a pressure approximately 40 per cent below that in the cylinder proper. In the third case which is for the most stressed portion of the head the yielding occurs about 26 per cent below that of the main cylinder when considering that the thickness of the head was $\frac{1}{8}$ in. greater than that of the cylinder. The yielding in each case occurred at the same stress in the steel and the conclusion to be drawn is that the intensification factors due to design or shape are as indicated by the ratio between the strain in the main cylinder and that in the dished head or unreinforced section of the vessel. The dished head used is not of the ordinary shape generally used by builders of pressure containers. The ordinary dished head has in general greater stress concentration at the joint between the main radius and the small radius because the small radius is ordinarily much shorter than for that on heads used in the investigation referred to above.

A subsequent test was made on the same pressure container in which the openings were reinforced and on one end an elliptical head of proportions indicated by an appropriate mathematical analysis was introduced. Fig. 2 gives the results obtained and shows that with adequate reinforcing and an appropriate design of head the intensification factors due to discontinuity and shape have been eliminated.

Corrosion as a Factor

A safe design for a pressure container must consider this. Also, the corrosion rate of steel under stress is materially different from what it is under no stress. This does not suggest that the ordinary unstressed corrosion specimens placed inside of pressure containers under operating conditions are valueless, but it does mean that they are of less value than they would be if the stress situation was made appropriate to that which would be encountered should this metal be used in the construction of a pressure container.

A short description of the methods adopted by the speaker is given.

In a study of methods adopted in other laboratories for testing steel at elevated temperatures, two things were apparent which, if eliminated, would produce more reliable test results than had heretofore been obtained. The first is the need for uniformity, in a considerable section of the specimen, of the temperature at which the metal is to be tested, and the other is the elimination of oxidation of the surface of the specimen, which in a very long time test materially affects the cross-section of the piece. If a specimen is relatively small as compared to the thickness of the wall of a pressure container, this becomes an important item.

In Fig. 3 is shown the furnace construction that was adopted. The specimen is immersed in a bath of liquid composed of lead for the temperatures above its melting point and another appropriate liquid is used when considering temperatures lower than that of lead. The thermocouple that controls

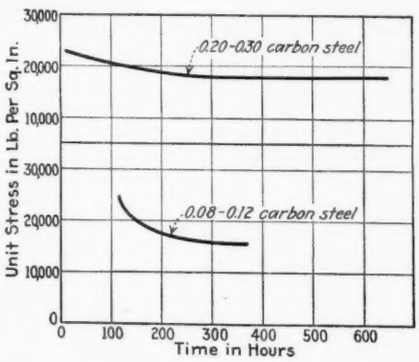


Fig. 4. Stress-time curves for two steels tested at 900 deg. F.

the temperature over a long period of time is immersed in this liquid as well as the specimen. The liquid has the quality of preventing oxidation of the specimen and also of keeping the specimen over the total gage length at a reasonably uniform temperature.

Several test specimens were made from each steel. Each successive test specimen was introduced in the testing machine at successively lower loads, and the time taken for it to fracture was carefully recorded. The load when once applied to a specimen was never changed. The stresses at which the specimens failed were then plotted against the time of failure and a curve as shown in Fig. 4 was drawn.

Fig. 4 represents test results at 900 deg. F. on two steels. The lower curve shows the value of the long-time ultimate strength for a 0.08 to 0.12 per cent carbon steel. The upper curve is for a 0.20 to 0.30 per cent carbon steel. It will be noticed that the test values for 300 hours are the same as those for a longer period.

NEWS *of the* FIELD

Duquesne Light Subsidiary to Build New Steam Heating Plant in Pittsburgh

Allegheny County Steam Heating Company Plans Twelfth Street Station to Serve Downtown District—Stoker Fired Boiler of 300,000 Lb. per Hour, at 250 Lb. Pressure, Initial Installation

PLANS for the erection of a new steam heating station in Pittsburgh for the Allegheny County Steam Heating Company, a subsidiary of Duquesne Light Company, by Byllesby Engineering & Management Corporation, were announced Feb. 25.

The new station, to be known as Twelfth Street Steam Station, will be erected on the corner of Twelfth Street and Etna Street, and the initial installation will consist of one stoker fired boiler having a capacity of 300,000 lb. of steam per hour at 250 lb. pressure. Allowing about 25,000 lb. for station auxiliaries, the net capacity will be 275,000 pounds.

Preliminary estimates indicate the cost of the station will be $1,100,000 and the cost of a 2,900-ft. tunnel with high pressure distribution mains will be $843,000, making a total cost of approximately $2,000,000.

The building will be a steel frame construction having brick curtain walls with little ornamentation. Provision will be made for office space and a temporary wall will be built to permit of future extension. A study of the space to be required for future extension, as well as the space available for it, is now being made. Space occupied by the present substation will be required and this will necessitate the moving of a turbine, synchronous condenser and a transformer bank.

Present plans call for locating coal handling equipment at the east side of the present substation. This equipment will consist of a skip hoist delivering coal to an overhead hopper, thence by feeder to supply belt and to the bunkers over the boilers.

The distribution system will consist of a 20-in. high-pressure line from the Twelfth Street Station in Twelfth Street to Penn Avenue, thence to Tenth Street, thence to William Penn Way and Seventh Avenue, where the tunnel will connect with an existing tunnel, piping to continue in existing tunnel to Sixth Avenue where connections will be made to existing steam and return mains. The tunnel from the plant to Tenth Street and Penn Avenue will be made to accommodate two 20-in. steam mains and two 16-in. return lines. The tunnel from Tenth Street and Penn Avenue to William Penn Way and Seventh Avenue will be made to accommodate one 20-in. steam main and one 16-in. return line.

Distribution from this station will supplement that of the present Stanwix station of the company. The erection of the new station and the tunnel is scheduled for completion Nov. 15.

Work of tearing down a structure on the site of the new station was started last month.

The Allegheny County Steam Heating Company supplies a steam heating service to the downtown district of Pittsburgh and was established primarily to supplement the electric service of the Duquesne Light Company.

Another 30,000-Kw. Turbine for Washington, D. C.

The Bennings Station of the Potomac Electric Company at Washington, D. C., is to have a second 30,000-kw. turbine-generator unit to care for the steadily increasing load in this section of the country.

The new unit, which will be built by the General Electric Company, will be identical in rating and steam conditions to the present 30,000-kw. G.E. machine now in operation. The turbine will be of standard 17-stage design, operating at 350 lb. pressure, 700 deg. F., and 1½ in. back pressure. The generator will be rated 13,200 volts 60-cycle three-phase, 90 per cent power factor.

The present equipment of the Bennings Station includes, beside the 30,000-kw. unit, two 20,000- and two 12,500-kw. sets, as well as several units for 25-cycle operation.

More Power for Saskatchewan

The City of Moose Jaw, Saskatchewan, recently installed a 5,000-kw. high-efficiency turbo-alternator complete with surface condenser, manufactured by C. A. Parsons & Company, Newcastle-on-Tyne, England. The steady increase in the demand for electrical energy has made this addition to the plant necessary, it is said, and the power station is now well equipped to take care of all immediate requirements.

Automatic Power Supply for Cincinnati Railway

A completely automatic railway system, said to be the largest in the world, supplying power automatically for the operation of trolleys over approximately 300 miles of track, is planned by the Cincinnati Street Railway Company for operation this year.

This system, designed by the General Electric Company and involving electric apparatus with a total rating of nearly 30,000 kw., will receive power from the Union Gas & Electric Company and distribute it to the trolleys by means of 19 automatic substations without the aid of a single attendant.

Each station is automatic in all respects. No attendants are required and doors are locked from the outside. Whenever a demand for power arises at any point as represented by cars operating on some part of the system, the station serving the proper area will commence operation and continue to deliver power so long as the load demand exists, after which it will shut down and wait until it is again called upon to function.

Superimposed over the automatic operation of the 19 stations will be a central dispatcher who will, by means of an automatic indicating system, be at all times informed whether a station is operating, what units in any given station are running and what the feeder, load and other conditions are at any given time. This dispatcher may, in emergency, interrupt the automatic control and govern operation himself.

The plan now in progress calls for the abandonment of one substation, the remodeling of nine and the construction of ten new ones. Each substation will contain one or two synchronous converters receiving 13,200-volt 60-cycle alternating current from the Public Utility and delivering 600-volt direct current to the railway system. Three of the downtown stations will each contain two 1,500-kw. converters, ten stations will each contain one 1,500-kw. converter, five will each contain one 1,000-kw. converter and one station, a 200-kw. converter.

Canadian Water Power Rights Referred to Supreme Court

The whole question of federal and provincial jurisdiction as to water power rights in Canada has been referred to the Supreme Court of Canada by the federal government. This procedure arises out of an agreement reached at the Dominion-Provincial conference of a few months ago. Seven questions in all are to be dealt with, chief among which are:

Has the Dominion exclusive legislative control over the proprietary interest in water powers, brought into being by works authorized by Parliament to be erected in an international stream for purposes of carrying out an agreement between Canada and any foreign country, looking to the erection of joint works for the improvement of navigation in such stream? If not, what are the powers and rights of the province with regard to such water powers?

No Shortage Soon

Power topics are being freely discussed in the Canadian capital at present. Some apprehension exists as to the possibility of a power shortage in Ontario in the near future, but representatives of the Hydro Electric Power Commission have pointed out that while the Commission looks to the St. Lawrence development as its chief source of supply for the future, it feels, taking account of the Gatineau power contracts and such other power as it anticipates from the Ottawa River and other sources, that there is no reason to fear a shortage of electrical energy during the next four or five years at least.

World Power Conference in Berlin

According to word received from Germany, the Second World's Power Conference will be held in Berlin in 1930. The first conference, it will be recalled, was held at Wembley, England in July, 1924, in connection with the Wembley Exposition. The session at Basel, Switzerland, in September, 1926, was merely a sectional meeting devoted largely to water power and navigation and was held simultaneously with the "Basel Exposition for Navigation and Hydraulic Power." Therefore the calling of a second conference for 1930 is in line with the original plans of the committee.

Free Honor Courses at Cooper Union Inaugurated

Honor courses for students of unusual ability will be given in the Institute of Technology at Cooper Union, beginning with the school term of 1928-29, Prof. F. M. Hartmann, dean of the Institute, announces. Four-year courses in mechanical engineering, civil engineering, electrical engineering, and chemical engineering are offered free.

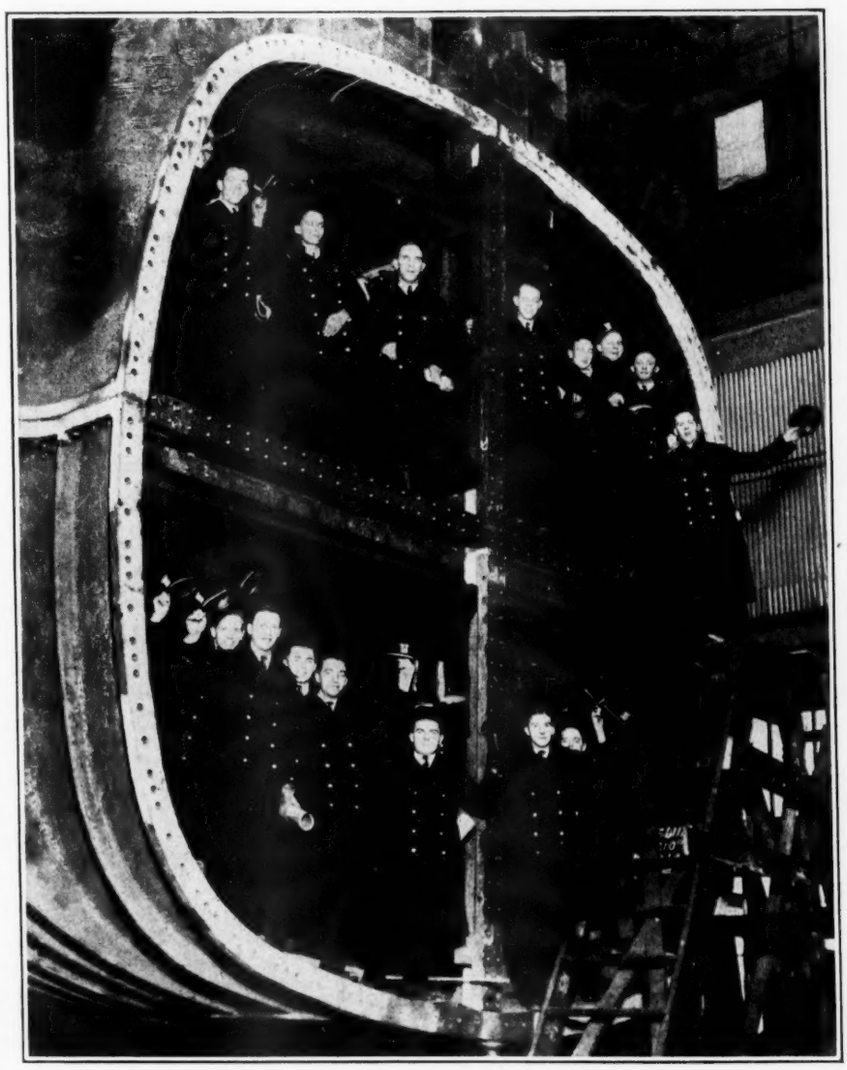
"This inauguration," Dean Hartmann explains, "will permit the student who has provided himself exceptionally strong, especially in his junior year, to select, at the beginning of his senior year, in addition to his regular schedule, some special topic for survey and study. The selection must be approved by the dean and the head of the department in which the special course is to be pursued.

"After the selection has been approved, the student shall carry on his work under an adviser who may be either the head of the department or some assistant assigned to him. The work shall be carried forward by means of conferences, and there shall be required no class or laboratory work. However, if deemed expedient, the student may be requested to attend certain scheduled lectures."

Penn Nautical Cadets Visit Westinghouse

A sightseeing tour of the South Philadelphia Works of the Westinghouse Electric & Manufacturing Company was taken recently by twenty-five engineer cadets of the Pennsylvania Nautical School Ship "Annapolis," under the leadership of Lieutenant Wilson. The cadets were welcomed by Paul Hecht, assistant to Vice President H. T. Herr, and I. Short, Marine Engineer of the Westinghouse company, in an informal talk reviewed for them the history of marine geared turbine propulsion and the pioneer work in that field by the Westinghouse company.

After luncheon the cadets, under the guidance of turbine engineers, inspected the works and observed the manufacture of marine machinery from the crude product of the foundry to the apparatus.



Getting to the Inside of Things

Portland Electric Power Seeks Purchase of Northwestern Electric Company

Interests Urge Deal Only If Voted by Special Popular Election—Rate Reduction 7 Cents to 5 Cents per Kilowatt Hour

PROPOSAL for the Portland Electric Power Company to purchase the Northwestern Electric Company has been made over the joint signatures of F. T. Griffith and G. W. Talbot, presidents of the respective companies.

The merger would comprise properties valued at $104,000,000, the general valuation of the Portland Electric Power Company being $81,000,000 and the Northwestern's being $23,000,000.

The Portland Electric Power Company's generating capacity is 186,000 hp., and the Northwestern's 51,000, making a total of 237,000 hp. involved. Rate reductions are said to be the salient factor announced in the proposed merger by heads of the companies. They have pledged to resident users rates of not more than 5 cents per kilowatt hour as against the 7 cents now prevailing.

Asks Popular Decision

Although state and city officials approve the proposed merger, the officials of the company have requested that the question be put to the people of Portland for popular vote, through a specially called election at which no other issue would be under consideration. Although the city council has the legal right to grant this permission and is willing to do so, the officials of the electric companies prefer the called election. It would be conducted, if granted, in April, at the expense of the utilities concerned.

Purchase of the Northwestern Electric Company will result in the operation of the combined system under the franchise of the Portland Electric Power Company. The Northwestern Electric Company was formerly owned by the Herbert Fleischacker interests of San Francisco, receiving its franchise by a vote of the people.

Deal Not Unexpected

On Christmas Day of 1927, as previously reported, merger of light, power and other utilities of the Pacific Power & Light Company in the interior of Oregon, Washington and Idaho was announced, and the merger with this group of the Washington Water Power Company serving Spokane, was subsequently made known. At this time it was noticed quite emphatically that the Northwestern Electric Company was omitted from the list of Talbot interests concerned in the merger, and it was conjectured then by the interested public that some further general consolidation was contemplated.

Officers of the Northwestern Electric Company are: President, Guy W. Talbot; vice-president and general manager, L. T. Merwin; secretary-treasurer, C. W. Platt; assistant manager, W. J. Dennis; sales manager, J. C. Plankington; general superintendent of properties, O. L. LeFever; rate and statistical engineer, D. A. McCurrach; purchasing agent, A. W. Angell.

Chief executives of the Portland Electric Power Company are: Chairman executive committee, C. M. Clark; president, Franklin T. Griffith; vice-presidents, O. B. Coldwell and W. H. Lines; secretary-treasurer, G. L. Estabrook; assistant secretary-treasurer, R. W. Sheppard.

Texas Plant to Install New 30,000 Kw. Turbine

The New Braunfels power station at New Braunfels, Texas, operated by the San Antonio Public Service Company, will shortly be equipped with a new 30,000-kw. turbine-generator unit and necessary condensing equipment.

The new apparatus will be built at the South Philadelphia Works of the Westinghouse Electric & Manufacturing Company, ordered by the U. G. I. Contracting Company, Philadelphia.

The turbine will be of the single-cylinder, impulse reaction type and will operate at 1,800 r.p.m. Steam will be supplied to the throttle at 385 lb. gage pressure, 255 deg. F. superheat and will exhaust at a pressure of 1½ in. mercury absolute.

The generator will have a rating of 30,000 kw. 90 per cent power factor producing three-phase 60-cycle current at a potential of 13,800 volts. A direct-connected exciter will also be furnished.

The condensing apparatus to be furnished will include a 37,500-sq.ft. radial flow surface condenser designed to condense approximately 250,000 lb. steam per hour and maintain a vacuum of 28½ in. mercury.

Committee Postpones Action on Boulder Dam Bills

Action on the Boulder Canyon Dam project was deferred until a future meeting of the Senate Committee on Irrigation and Reclamation after an executive meeting of that Committee Feb. 29 had failed to reach an agreement on the controverted features in the various bills before it dealing with that subject.

Announcement of the results of the Committee's meeting was made by Senator Phipps (Rep.), of Colorado, chairman of the committee.

Plan Indiana Fuel Conference at Purdue, April 5-6

Purdue University announces a two-day meeting to be known as the Indiana Fuel Conference, held at Lafayette, Ind., on April 5-6, under the direction of the Engineering Extension Department and the School of Mechanical Engineering, with the School of Chemical Engineering co-operating.

This program has been arranged at the request of a number of power plant operators and users of bituminous fuels in Indiana who believe that an educational meeting dealing with Indiana fuels problems will be of value to the producers, distributors and users of Indiana coal and to Indiana manufacturers in general.

The program will include discussion of Indiana fuel resources, effect of fuel and power on progress, fuel research problems, burning of Indiana coals in power plants and the home, storage of coal, preparing coal for the plant and modern method of marketing coal.

The topics to be presented will be handled by authorities in the fields under discussion. The list of speakers include: G. A. Young, School of Mechanical Engineering; W. N. Logan, state geologist; A. A. Potter, dean of engineering; R. B. Moore, dean of science; A. B. Bailey, superintendent of power plants, Commonwealth Edison; H. C. Carroll, consulting engineer; C. H. B. Hotchkiss, assistant professor of heating and ventilating; A. J. Hoskins, mining engineer; M. A. Tuttle, combustion engineer; A. W. Cole, professor of steam engineering; T. A. Marsh, consulting engineer; and H. A. Glover, vice-president, Knox Consolidated Coal Company.

Users of coal in any form, purchasing agents, plant operators, engineers, owners of manufacturing plants and other interested in the problems connected with the use of Indiana fuels may be benefited by attending this meeting.

The final program will be ready for distribution early in March. Copies may be received by addressing Purdue University Engineering Extension Department, Lafayette, Ind.

Boilers, Registered, 18,060

Boilers registered with the National Board of Boiler and Pressure Vessel Inspectors in 1927 totaled 18,060.

The following figures represent five classes according to capacity, compared with those registered in 1926.

One to 5 hp., 13,272 in 1926, in 1927, 11,903; 6 to 50 hp., 4,299 in 1926, in 1927, 3,334; 51 to 200 hp., 2,007 in 1926, in 1927, 2,031; 201 to 500 hp., 668 in 1926, in 1927, 428; 501 hp. and up, 499 in 1926, in 1927, 364.

Obituary

EDWARD MCDONALD, formerly plant superintendent of the Nebraska Power Company, died Jan. 11 in his 59th year. Mr. McDonald had been affiliated with the company for more than ten years. He has been succeeded by L. Ruf.

CHARLES P. HUGO SCHOELLKOPF, a member of the firm of Schoellkopf, Hutton & Pomeroy, Inc., bankers, of Buffalo, and vice-chairman of the board and a member of the executive committee of the Niagara Falls Power Company, died Feb. 14 in the Lenox Hill Hospital, New York, after an illness of eight weeks. For many years Mr. Schoellkopf was vice-president of the Niagara Falls Power Company, but he retired from active business several years ago. He was a former treasurer of the Shafer Decker Company, of Buffalo and a director of the Buffalo, Niagara & Eastern Power Corporation and the Marine Trust Company, of that city.

Personal Mention

WARREN B. FLANDERS, assistant manager of engineering at the South Philadelphia works of the Westinghouse Electric & Manufacturing Company, has recently been commissioned a Lieutenant-Commander in the U. S. Navy Reserve for special engineering duty.

MYRON F. WESTOVER, secretary of the General Electric Company for the last 34 years, retired on March 1, and William W. Trench, assistant secretary, has been elected by the board of directors to succeed him. Mr. Westover has been actively identified with the electrical industry for 40 years, his first position being secretary to the late Charles A. Coffin, then treasurer and manager of the Thomson-Houston Electric Company. He was associated with Mr. Coffin until the latter's death in 1926.

D. K. SWARTWOUT, SR., and Mrs. Swartwout sailed March 3 for the West Indies, where they will vacation for several weeks. Mr. Swartwout is president of the Swartwout Company, Cleveland, manufacturers of steam specialties, ventilating equipment and industrial ovens.

J. A. LODWICK, formerly general manager of the industrial department of the American Arch Company, Inc., has been appointed, effective Feb. 15, assistant to the president of the Kennedy-Van Saun Manufacturing & Engineering Corporation, with headquarters at 2 Park Avenue Building, New York City. Mr. Lodwick has had extensive experience in the refractory field, particularly as related to furnace designs and furnace problems.

C. D. ZIMMERMAN has resigned as Eastern service manager of the Consolidation Coal Company to become assistant superintendent of power for the Pennsylvania-Ohio Power & Light Company, at Youngstown, Pa.

J. ROGER PRESTON, consulting engineer, announces that he has removed from his old offices at 104, High Holborn, London, W.C.1, to new quarters at 7, Southampton St., Bloomsbury Square, London, W.C.1, England.

CHARLES M. HOFFMAN has been elected vice-president of the Dearborn Chemical Company, with headquarters at 310 South Michigan Ave., Chicago. Mr. Hoffman has been associated with the company since January, 1924, in the capacity of assistant to the vice-president.

DR. CORNELIS LELY, president and honorary member of the Netherlands Royal Institute of Engineers, and member of the Royal Academy of Sciences, was tendered a luncheon at the Engineers' Club, New York City, March 6, under the auspices of the four founder societies. Dr. Lely is visiting the United States under the auspices of the Institute of International Education and will give addresses in the leading universities on the subject of "The Development of the Zuider Zee and Flood Control."

WARREN H. GOODRICH, formerly chief engineer at the Sea View Avenue Power Station of the Connecticut Company at Bridgeport, and later with the Stamford Gas & Electric Company at Stamford, Conn., recently salesman with the Crandall Packing Company, severed his connections with the latter concern March 1, and will take over the Connecticut territory for the McLeod & Henry Company. He will succeed Mr. Norman S. Burnham who died recently. Mr. Goodrich is a past president of the N.A.S.E. association of Bridgeport and of the New England States association.

JULIAN C. SMITH, vice-president and general manager of the Shawinigan Water & Power Company, Montreal, Que., was installed as president of the Engineering Institute of Canada for 1928 at the Institute's recent annual convention. Mr. Smith has been an outstanding figure in engineering circles in Canada for a number of years, though an American by birth. In 1903 he became superintendent, advancing to the position of general superintendent three years later. Subsequently he was named general superintendent and chief engineer and in 1913 he was made vice-president.

Society Affairs

A.S.M.E.—Engineers' Club of San Francisco, March 29, 7 p.m. Subject: "The Design of Steam Electric Generating Stations," by R. C. Powell, assistant chief of division of electric distribution and steam, Pacific Gas & Electric Company, of San Francisco.

A.S.M.E. and SOCIETY OF AUTOMOTIVE ENGINEERS at joint meeting, Buffalo, N. Y., March 6, 8 o'clock, Hotel Statler, will be addressed by O. D. Treiber, president and chief engineer of the Treiber Diesel Engine Corporation, Camden, N. J., speaking on "High Speed Diesel Engines."

A.S.M.E.—Philadelphia — Engineers' Club of Philadelphia, 1317 Spruce St., Philadelphia, March 27; dinner at 6 p.m. Meeting at 8 p.m. Subjects: "Progress in the Burning of Coal," by Prof. A. G. Christie, professor of mechanical engineering, Johns Hopkins University, Baltimore, Md. "Special and Anti-Knock Fuels," by Dr. Graham Edgar, director of research, Ethyl Gasoline Corporation, New York; "Recent Developments in Low Temperature Carbonization," by Col. H. D. Savage, president of the Dry Quenching Equipment Corporation, New York.

HARVARD ADVERTISING AWARD
MAGNA EST VERITAS ET PRAEVALEBIT
FOR DISTINGUISHED PERSONAL SERVICE RENDERED AUTHORITATIVELY THROUGH RAISING THE STANDARDS OF ADVERTISING

Medal Awarded to James H. McGraw, publisher of POWER, *on Friday, Feb. 17, by the Graduate School of Business Administration, Harvard University, for Distinguished Services in the Improvement of Industrial Advertising.*

Business Notes

THE PENNSYLVANIA PUMP & COMPRESSOR COMPANY, Easton, Pa., has appointed Merrill P. Wolfe, Praetorian Building, Dallas, Texas, as sales representative in the Dallas territory.

THE FLYNN & EMRICH COMPANY has appointed W. D. Wood, 34 Oakley Ave., Summit, N. J., as New Jersey representative for the sale of Huber mechanical stokers and Huber automotive stokers.

THE BENJAMIN F. SHAW COMPANY, Wilmington, Del., has announced that William McCallister, Jr., formerly of the W. M. Kellogg Company, has become associated with the sales department of the Shaw organization.

THE NORTHERN EQUIPMENT COMPANY, Erie, Pa., manufacturer of Copes feed water regulators announces the appointment of the Rush Machinery Company, 32 East Carson St., as sales representatives for the Pittsburgh territory.

THE YEOMANS BROTHERS COMPANY, Chicago, manufacturers of sewage ejectors and pumping machinery, announce the apointment of H. F. Kircher & Company, Lehman Building, Peoria, Ill., to represent them in the central part of Illinois. This firm will handle the complete Yeomans line, which includes sewage ejectors, bilge pumps, centrifugal pumps and condensation return pumps.

THE AMERICAN ELECTRIC MOTOR COMPANY, Cedarburg, Wis., has recently become a subsidiary of the Splitdorf-Bethlehem Electrical Company, Newark, N. J. In addition to the American Electric Motor Company, the Splitdorf Company controls the Splitdorf Radio Corporation, Splitdorf Company of Canada, Splitdorf Electrical Company, Splitdorf Manufacturing Company and the Perfection Appliance Company. American Electric Motor Company, in its new modern plant at Cedarburg, will continue to manufacture a self-ventilated polyphase induction motor from one-half to 125 horsepower.

Trade Catalogs

APPARATUS FOR HEATING SYSTEMS—The Cochrane Corporation, Philadelphia.—Auxiliary equipment for use in heating and industrial plants where boilers are operated principally for heating, hot water service, or processes, is described in Bulletin 676. In such plants it is generally necessary to provide for the storage of condensed returns, trap discharges and make-up water, and exhaust steam available from pumps or other apparatus should be applied to heating the boiler feed water. The present bulletin describes special types of heaters with large storage capacity, also arrangements for automatic control of heat storage, that is, the admission of cold water supply in proportion to the steam available for heating it, or the admission of the heating steam according to the demand for hot water. Other auxiliary equipment, including separators, filters, traps, drainers, back-pressure valves, and flow meters are also described.

Coming Conventions

American Association of Engineers, annual convention, El Paso, Texas, June 4-6; M. E. McIver, secretary, 63 Adams St., Chicago.

American Institute of Electrical Engineers, St. Louis Regional Meeting, District No. 7, March 7-9; Baltimore Regional Meeting, District No. 2, April 17-19; New Haven Regional Meeting, Northeastern District, No. 1, in May; Summer Convention, in Denver, June 25-29.

American Institute of Refrigeration, Washington, D. C., May 10-11.

American Refractories Institute, annual meeting at White Sulphur Springs, W. Va., May 8-9; Dorothy A. Texter, secretary, 2202 Oliver Bldg., Pittsburgh.

American Society of Refrigerating Engineers, meeting at Detroit, June 4-7; W. H. Ross, secretary, 37 West 39th St., New York City.

American Society of Heating and Ventilating Engineers, Summer meeting at West Baden Springs Hotel, West Baden, Ind., June 26-29; A. V. Hutchinson, secretary, 29 West 39th St., New York City.

American Society of Mechanical Engineers, spring meeting in Pittsburgh, May 14-17; Calvin Rice, secretary, 29 West 39th St., New York City; Twin-City regional meeting at St. Paul, Aug. 27-30; Boston regional meeting, Oct. 1-3.

American Society for Testing Materials, Atlantic City, June 25-29.

American Water Works Association. Annual meeting, Hotel Fairmont, San Francisco, June 11-16; W. M. Niesley, 170 Broadway, New York City.

Association of Iron and Steel Electrical Engineers, annual convention and Iron and Steel Exposition at Hotel Stevens, Chicago, June 25-29.

Indiana Fuel Conference at Purdue University, Lafayette, Ind., April 5-6.

National Association of Power Engineers, annual convention at Detroit, Sept. 11-15, and concurrently National Exhibitors' Assn. exhibit; Fred Raven, 417 South Dearborn St., Chicago.

National Board of Boiler and Pressure Vessel Inspectors, meeting at Erie, Pa., June 18-20.

National Electric Light Association, Convention and exhibition, Atlantic City, N. J., June 4-8; A. Jackson Marshall, secretary, 420 Lexington Ave., New York City.

National District Heating Association, annual meeting at Ambassador Hotel, Atlantic City, June 12-15; D. J. Gaskill, sec., 112 West 4th St., Greenville, Ohio.

Stoker Manufacturers Association, fall meeting at Greenbrier Hotel, White Sulphur Springs, W. Va., Oct. 22-24.

Universal Craftsmen Council of Engineers, Newark, N. J., Aug. 7-10.

Second Bituminous Coal Conference will be held at Pittsburgh, Nov. 19-22.

ELECTRIC HOISTS—The Chisholm-Moore Manufacturing Company, Cleveland, has issued a handy and complete catalog on the subject of electric hoists. It is Bulletin No. 31, and is one of a series of material handling equipment bulletins being prepared and published by the same company. Starting with a short treatment on the importance of electric hoists in industry, the new catalog covers the various types of hoists, illustrates their use, describes their operations and care, and gives diagrams and tables of clearances, dimensions and other data.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	Market Quoting	
Navy Standard	New York	$2.50@$2.65
Kanawha	Columbus	1.25@ 1.60
Smokeless	Cincinnati	2.00@ 2.25
Smokeless	Chicago	1.85@ 2.25
S. E. Kentucky	Chicago	1.40@ 1.60
Steam	Pittsburgh	1.75@ 1.85
Gas Slack	Pittsburgh	1.00@ 1.25
Big Seam	Birmingham	1.50@ 2.00
Anthracite (Gross Tons)		
Buckwheat	New York	$3.00@$3.25
Birdseye	New York	1.60

FUEL OIL

New York—Mar. 1, light oil tank-car lots, 28@34 deg., Baumé, 4½@5c. per gal.; 36@40 deg., 5½@6c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Feb. 16, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.60 per bbl.; 26@28 deg., $1.65 per bbl.; 28@30 deg., $1.70 per bbl.; 30@32 deg., $1.75 per bbl.; 32@36 deg., gas oil, 4.276c. per gal.; 38@40 deg., 5.23c. per gal.

Pittsburgh—Feb. 21, f.o.b. local refinery, 30@34 deg., fuel oil, 4½c. per gal.; 36@40 deg., 4¾c. per gal.

Philadelphia—Feb. 24, 26@30 deg., $2.00@$2.06 per bbl.; 13@19 deg., $1.26 @$1.32 per bbl.; 22 plus, $1.58@$1.64 per bbl.; 27@30 deg., $2.10@$2.16 per bbl.

Cincinnati—Feb. 27, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 4.9c. per gal.; 26@30 deg., 5.15c. per gal.; 30@32 deg., 5½c. per gal.

Chicago—Feb. 18, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl.; 22@26 deg., 85@90c. per bbl.; 26@30 deg., 90@95c. per bbl.; 30@32 deg., $1.10@$1.15 per bbl.

Boston—Feb. 27, tank-car lots, f.o.b. 12@14 deg. Baumé, 4½c. per gal.; 28@ 32 deg., 5.8c. per gal.

Dallas—Feb. 25, f.o.b. local refinery, 26@30 deg., $1.40 per bbl.

NEW PLANT CONSTRUCTION

Calif., Claremont—Pomona College, is having preliminary plans prepared for a group of college buildings. Estimated cost $1,000,000. Webber & Spaulding, 627 South Carondelet St., Los Angeles, are architects.

Calif., Hollister—National Ice & Cold Storage Co., Postal Telegraph Bldg., San Francisco, plans the construction of an ice plant here. Private plans.

Calif., Hollywood (Ind. Sta. Los Angeles)—Local Corporation, c/o A. Le Brun, 1223 Guaranty Bldg., Archt., is having sketches made for a 10 story apartment building including electric refrigeration system, elevators, etc. Estimated cost $500,000.

Calif., Los Angeles—Aimee Semple McPherson, awarded contract for a 10 story hotel including swimming pool, etc. to W. G. Reed, 254 Miramar Ave., Long Beach. Estimated cost $675,000.

Calif., Los Angeles—L. J. Morehouse, 692 South Berendo St., is receiving bids for a 12 story hotel including steam heating system, elevators, etc. at 7th and Berendo Sts. Estimated cost $650,000. R. M. Bates, 660 South Vermont Ave., Archt.

Calif., Los Angeles — United Pacific Securities Co., c/o N. W. Alpaugh, 2404 West 7th St., Archt., is having plans prepared for a 12 story apartment building on Wilshire Blvd. Estimated cost $1,500,000.

Calif., Oakland—Skaggs-Safeway Stores Inc., 4th and Alice Sts., plans the construction of a bakery including refrigeration plant, etc. at Fourth and Jackson Sts. Estimated cost $400,000.

Calif., Orange—Santiago Orange Growers Assn., plans the construction of a packing and pre-cooling plant. Estimated cost $40,000.

Calif., Pasadena—L. Orndorff, et al, c/o Orndorff Construction Co., 247 North Western Ave., Los Angeles, Contr., awarded contract for an apartment building. Estimated cost $2,250,000.

Calif., San Francisco—S. F. Stock & Bond Exchange, 341 Montgomery St., awarded contract for a 4 story office building at Montgomery and California Sts. to W. C. Perry, 260 Montgomery St. Estimated cost $500,000.

Calif., San Francisco—Y. M. C. A. Hotel Co., 220 Golden Gate Ave., awarded contract for a 12 story hotel on Turk St. to K. E. Parker, South Park St. Estimated cost $750,000.

Conn., Bridgeport — Dept. of Public Works, plans the construction of a refrigeration plant at Slaughter House. Estimated cost $15,000.

Conn., Montville—Robert Gair Co., will receive bids until Apr. 1 for the construction of a boiler house. Estimated cost including equipment $40,000.

Conn., Plainville—Connecticut Light & Power Co., 92 West Main St., New Britain had plans prepared for the construction of a sub-station here. Estimated cost $40,000. Private plans.

Conn., Windsor Locks—Northern Connecticut Power Co., 15 Central St., Thompsonville, awarded contract for the construction of a power house and two dams, etc. here to United Gas Improvement Co., Broad and Arch Sts., Philadelphia, Pa.

Ill., Chicago—Chicago Civic Opera Co., 58 East Congress St., awarded general contract for a 42 story theatre and office building at Madison, Market and Washington Sts. and Chicago River to John Griffiths & Sons Co., 228 North La Salle St. Estimated cost $20,000,000.

Ill., Chicago — Clark-Lincoln Building Corp., c/o Lowenberg & Lowenberg, 111 West Monroe St., Archts., awarded contract for masonry, etc. for a 12 story hotel including steam heating system, elevators, etc. at Clark and Wells Sts. Estimated cost $1,000,000.

Ill., Chicago—R. R. Donnelley & Sons Co., Plymouth Court and Polk St., is having plans prepared for an 8 story printing plant at 21st St. and Calumet Ave. Estimated cost $2,000,000. Howard Shaw Associates, 104 South Michigan Ave., are architects.

Ill., Chicago—Fargo Building Corp., C. M. Nicol, 310 South Michigan Ave., Archt., awarded general contract for a 13 story office building at 1337 Fargo Ave. to Fleisher Engineering & Construction Co., 410 North Michigan Ave. Estimated cost $900,000.

Ill., Chicago — Produce Terminal Cold Storage Co., c/o Henschin & McLaren, 1637 Prairie Ave., Engrs., awarded contract for a cold storage warehouse at West 15th Pl. and Throop St. to Wells Bros. Construction Co., 53 West Jackson Blvd. Estimated cost $2,000,000.

Ill., Chicago—Syndicate, c/o M. L. Bein & Co., 64 West Randolph St., Archts., awarded contract for masonry, etc. for a 13 story apartment building at 5348-50 Cornell Ave. Estimated cost $750,000.

Ill., Galesburg—Chicago, Burlington & Quincy R.R. Co., 547 West Jackson Blvd., Chicago, plans relocating, enlarging and building a new ice house at Murrayville yard here. Estimated cost $70,000. A. W. Newton, is chief engineer.

Ind., Anderson—Anderson Theatres Building Co., G. Challis, Local Mgr., Muncie, will receive bids until Apr. 1 for a 7 story hotel at 12th and Meridian Sts. Estimated cost $1,000,000. A. M. Strauss, Ft. Wayne, is architect.

Ind., Anderson—Bd. of Works, C. H. Stelle, Supt., City Hall, plans the construction of three electric sub-stations and connecting lines for municipal light and power plant. Estimated cost $100,000.

Ind., Fort Wayne—Hilgeman & Schaaf, 209 East Wayne St., will receive bids until Apr. 1 for an 8 story hotel including steam heating system, elevators, etc. at Fairfield and Berry Sts. Estimated cost $1,000,000. A. M. Strauss, 415 Cal-Wayne Bldg., architect.

Mass., Bridgewater—Bd. of Education, State House, plans to rebuild power plant at State Normal School. Estimated cost $80,000.

Mass., Brockton — Brockton Gas Light Co., G. H. Priest, Mgr., 54 Main St., awarded contract for addition to boiler plant including two horizontal return tubular boilers, stokers, feed water heaters, condensers, etc., to C. A. Batson Co., 26 Arlington St. Estimated cost $125,000.

Mass., Danvers—South Essex Sewage Bd., Fort Ave., Salem, will receive bids until Mar. 7 for the substructure of a pumping station, etc. here. Private plans.

Mich., Ferndale—Detroit City Service Co., 725 Lafayette Bldg., Detroit, will soon award contract for the construction of an artificial ice plant at Woodward Heights Blvd. here. Estimated cost $100,000. G. B. Bright, 2615 Twelfth St., Detroit, is engineer.

Mich., Niles—City awarded contract for the construction of a power plant and dam, 22 ft. head including 750 hp. turbo-generator unit, etc., to John C. Nelson Co., South Bend, Ind. Estimated cost $52,700.

Miss., Columbus—A. H. Barber & Co., 216 North Canal St., Chicago, Ill., awarded contract for first unit of cold storage plant and cheese factory here to D. S. McClanahan & Son, Columbus, Miss.

Mo., Kansas City—C. O. Jones, Continental Bldg., will build a 10 story apartment building by day labor. Estimated cost $1,350,000. Boillet & Lanke, Orear-Leslie Bldg., are architects.

N. J., Jersey City—New Corporation, c/o Hotel Development Service Co., S. Bobo, 369 Lexington Ave., New York, N. Y., will soon award contract for a 17 story hotel at 2861-67 Hudson Blvd. Estimated cost $1,500,000. Thomas Martin & Kilpatrick, 220 South 16th St., Philadelphia, Pa., are engineers.

N. J., Jersey City—Syndicate, c/o W. Freile, 25 Tonnell Ave., is having sketches made for a 10 story, medical office building including steam heating system, boilers, elevators, etc. at Tonnell and Sip Aves. Estimated cost $1,500,000. Private plans.

N. J., Newark—New York Telephone Co., 15 Dey St., New York, N. Y., awarded general contract for a 20 story telephone exchange and office building at 534-546 Lombardy St. here to Turner Construction Co., 420 Lexington Ave., New York. Estimated cost $1,500,000.

N. J., Newark—Twenty Six-Thirty Two Johnson Ave., Inc., c/o H. F. Clark, 38 Clinton St., Archt., is having plans prepared for a 10 story apartment building including steam heating system, boilers, elevators, etc. Estimated cost $500,000.

N. Y., Binghamton—Ansco Photoproducts Co. plans the construction of a factory and laboratory building. Estimated cost $1,000,000. O. S. Schlich, 136 Liberty St., New York, N. Y.

N. Y., Brooklyn—Bing & Bing, 119 West 40th St., will build a 20 story hotel here. Estimated cost $3,500,000. Private plans. Work will be done by separate contracts.

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N. Y., Brooklyn—Riding & Driving Club of Brooklyn, Sterling Pl. and Vanderbilt Ave., is having sketches made for an apartment and club, etc., at Grand Army Plaza and Sterling Pl. Estimated cost $4,000,000. H. Craig Serverance, 36 West 44th St., New York, is architect.

N. Y., Garden City—Adelphi College St. James St. and Clifton Pl., Brooklyn, will receive bids after Mar. 15 for a group of college buildings here. Estimated cost $1,500,000. McKim, Mead & White, 101 Park Ave., New York, are architects.

N. Y., Ithica—Cornell University, awarded contract for a dormitory to Dall, Haydon & Treat, 70 East 45th St., New York. Estimated cost **$1,500,000.**

N. Y., New York—Bellevue & Allied Hospitals, J. J. McGrath, First Ave. and 26th St., is having sketches made for a 6 story hospital at First Ave. between 29th and 30th Sts. Estimated cost $2,000,000. Thompson, Holmes & Converse, 101 Park Ave., are architects. H. G. Balcorn, 10 East 47th St., is engineer.

N. Y., New York — Carlouhyn Realties Inc., C. Raeklin, Pres., 140 East 174th St., had plans prepared for a 6 story apartment building at Walton Ave. and 168th St. Estimated cost $750,000. L. Pesciotta, 563 Tremont Ave., is architect.

N. Y., New York — Caul Realty Corp., H. E. Murray, Pres., 25 West 43rd St., had plans prepared for a 15 story apartment at Central Park W. and 69th St. Estimated cost $1,000,000. Schwartz & Gross, 347 5th Ave., are architects.

N. Y., New York—A. Crisp, 308 East 51st St., plans the construction of a 14 story co-operative apartment building at 602 East 84th St. Estimated cost $750,000. Architect not selected.

N. Y., New York—Eleto Co., 153 East 24th St., awarded contract for a 10 story warehouse and distributing building at First Ave. and 38th to 39th Sts., to White Construction Co., 95 Madison Ave. Estimated cost $2,500,000. Lord & Taylor and James McCreery & Co., lessees.

N. Y., New York—News Syndicate Inc., 25 Park Pl., awarded contract for a 20 story newspaper and office building to Hegeman & Harris, Madison Ave. Estimated cost $6,000,000.

N. Y., New York—Hunts Point Building Co., S. Wallenstein, Pres., 2067 Jerome Ave., had plans prepared for a 6 story apartment building at Hunts Point and Spoffard Aves. Estimated cost $500,000. Glick & Duma, 400 East Fordham Rd., are architects.

N. Y., New York—Henry Friedman & Sons Real Estate Co., c/o G. G. Miller, 1482 Broadway, Archt., had plans prepared for three 6 story apartment buildings at 608-616 West 134th St. Total estimated cost $1,500,000.

N. Y., New York—M. J. Holding Corp., M. Toonkel, Pres., 590 East 161st St., will build two 6 story apartment buildings at Jessup Ave. and Featherbed Lane. Estimated cost $600,000. Springsteen & Goldhammer, 40 East 49th St., are architects. Work will be done by separate contracts.

N. Y., New York—Museum of the City of New York, J. Speyer, Chn., 1058 5th Ave., plans the construction of a museum at 103rd St. and Fifth Ave. Estimated cost $1,000,000. J. V. Van Pelt, 126 East 59th St., is consulting architect.

N. Y., New York—Smoleroff Development Corp., M. Smoleroff, Pres., 1500 Boston Rd., had plans prepared for two 6 story apartment buildings at Holland, Wallace and Lydig Aves. Estimated cost $650,000 and $750,000 respectively. L. Stillman, 1993 Jerome Ave., is architect.

N. Y., New York—Young Mens Hebrew Assn., 205 West 57th St., is having plans prepared for an 11 story club and dormitory at Lexington Ave. and 92nd St. Estimated cost $1,500,000. Arnold Brunner Associates, 101 Park Ave. and Necarsulmer & Lehlbach, 420 Lexington Ave., are associate architects.

N. Y., Rochester—State Dept. of Mental Hygiene, Albany, awarded general contract for the construction of four new buildings for Rochester State Hospital here to Tuppa & Battle Co. Inc., 2252 Culver Rd., Rochester.

N. Y., Saranac Lake—National Vaudeville Artists Inc., c/o H. Chesterfield, 229 West 46th St., New York, is receiving bids for a 4 story addition to hospital here. Estimated cost $1,500,000. Scopes & Feustmann, Main St., Saranac Lake, and T. W. Lamb, 644 8th Ave., New York, are associate architects.

N. C., Winston-Salem—Carolina Building Inc., O. Moon, Pres. awarded contract for an 11 story theatre and apartment building at Fourth and Marshall Sts. to John P. Pettyjohn Co., Lynchburg, Va. Estimated cost $500,000.

O., Apple Creek—Dept. of Welfare, Ninth and Oak Sts., J. E. Harper, Dir., Columbus, is receiving bids for the construction of two cottages including separate heating plant. Estimated cost $250,000. H. B. Briggs, Ohio-Hartman Bldg., Columbus, is architect.

O., Cleveland—The Cleveland Union Terminal Co., c/o C. L. Bradley, Pres., Terminal Tower Bldg., is having plans prepared for a 17 story medical office building at Prospect and Ontario Sts. Estimated cost $4,000,000. Graham, Anderson, Probst & White, 80 East Jackson Blvd., Chicago, Ill., are architects.

Okla., Mulhall—City will soon award contract for the construction of a new waterworks system including well, deep well pump and motor, 60,000 gal. tank on tower, etc. Estimated cost $22,000. H. E. Musson, Grain Exchange Bldg., Oklahoma City, is engineer.

Pa., Philadelphia — Quaker City Cold Storage Co., Water and Spruce Sts., awarded contract for the construction of a cold storage plant at 314 South Delaware St. to J. A. Hauser, c/o Ballinger Co., 12th and Chestnut Sts.

S. C., Hartsville—Easton Finishing Co., Easton, Pa., has acquired a 40 acre site and plans the construction of a bleachery to include mill building, 90 x 800 ft. Estimated cost $500,000. Robert & Co., Inc., Bona Allen Bldg., Atlanta, Ga., are engineers.

Texas—United Producers Pipe Line Co., subsidiary of Transcontinental Oil Co., 111 Broadway, New York, N. Y., is having surveys made for an oil pipe line about 425 mi. from Yates pool in Pecos county to Texas City via Sonora, Junction, south of Austin and straight to Texas City. Pumping stations will be constructed at intervals of 35 miles. Estimated cost $18,000,000. Private plans.

Tex., Austin—E. Nalle, awarded contract for a 15 story office building at 8th and Congress Ave. to Walsh & Burney Inc., 618 Frost National Bank Bldg., San Antonio. Estimated cost $500,000. Elevators, etc. will be installed.

Tex., Galveston — John Sealy Hospital, c/o E. Randall, Chn. Bldg. Comm., awarded contract for a power house and laundry plant to J. W. Zempter & Co., 2321 F. St. Estimated cost $200,000.

Tex., Port Arthur—Consumers Ice & Coal Co., plans addition to ice plant to increase the capacity. Estimated cost $50,000. Private plans.

Tex., Texas — Dairies Inc., c/o J. W. Etter, Pres., 608 Dallas St., San Antonio, plans to establish a chain of creameries and ice cream plants in a number of south and east Texas cities. Estimated cost $500,000.

Wash., Seattle—City appropriated $625,000 for extensions and improvements to municipal light and power plant at Gorge Creek on the Skagit River.

W. Va., Parkersburg—Dept. of Waterworks and Sewers, G. Huber, Supt., will receive bids until Mar. 13 for the construction of a carbon dioxide and iron removal plant, clear water reservoir and high lift pumping station. Morris Knowles Inc., Westinghouse Bldg., Pittsburgh, Pa., is engineer.

Wis., Appleton—Syndicate, c/o Lorenz-Redding Co., 10 North Clark St., Contrs., awarded contract for apartment, theatre and stores building at West College Ave. Estimated cost $750,000. Mechanical ventilation and air cooling systems, etc. will be installed.

Wis., Beloit—Syndicate, c/o Lorenz-Redding Co., 10 North Clark St., Chicago, Ill., Contrs., awarded contract for apartment, theatre and stores building on East Grand Ave. Estimated cost $750,000. Mechanical ventilation and air cooling systems, etc. will be installed.

Wis., Milwaukee—G. Henry, c/o K. M. Elbinger, 1274 Farwell Ave., plans an 8 story hotel and apartment building at Knapp and Franklin Sts. Estimated cost $500,000. Architect not announced.

Wis., Milwaukee—Milwaukee Gas Light Co., 182 East Wisconsin Ave., plans the construction of a 14 story office building, including steam heating system, etc. Eschweiler & Eschweiler, 210 Mason St., are architects.

Ont., Leaside — Ontario Hydro Electric Power Commission, Toronto, is receiving bids for the construction of a transformer building here. A condenser building will be built later.

Ont., Toronto—City plans the construction of a 12 story office building including steam heating system, elevators, etc. on Albert St. Estimated cost $1,500,000. J. J. Woolnaugh, City Hall, is architect.

Equipment Wanted

Boilers—U. S. Engineer Office, War Dept., Washington, D. C., will receive bids until Mar. 5 for furnishing and installing boilers for U. S. towboat "LeClaire" at Rock Island, Ill.

Boilers, Pumps, Etc.—J. D. Warther, Box 771, Amarillo, Tex., Gen. Contr., is receiving bids for fire box boilers, pumps, etc., for new plant to replace fire loss for Amarillo Producers & Refiners Corp., c/o W. S. Roberts, Secy., Amarillo, Tex. Estimated cost $75,000.

Electrical Equipment — Detroit Edison Co., 2000 Second Blvd., Detroit, Mich., plans the installation of electrical equipment for proposed sub-station at Royal Oak, Mich. Estimated cost $140,000.

Engine Unit—Abernathy Gin Co., C. J. Felmet, Mgr., Abernathy, Tex., plans to purchase equipment including engine unit, etc., to cost $18,000 for proposed plant and boiler room.

Engines, Generators, Pumps, Exciters, Condensers, etc.—Bd. of Trustees, Dept. of Waterworks, J. C. Males, Secy., Evansville, Ind., will receive bids until Mar. 29 for steam engines, generators, steam turbine-driven, motor driven and hydraulic turbine-driven pumps, boiler feed and sump pumps, exciters, condensers, coal and ash handling equipment, etc., for proposed waterworks improvements. Estimated cost $976,490.

Ice Cream Plant Equipment — Texas Dairies, Inc., c/o J. W. Etter, Pres., 608 Dallas St., San Antonio, Tex., plans to purchase equipment for proposed creameries and ice cream plants in a number of south and east Texas cities.

Ice Machine—Karp Bros. Coal & Ice Co., 3900 Orleans St., Detroit, Mich., plans to purchase an ice machine for proposed ice plant on Gratiot Ave. Estimated cost $100,000.

Pumping Equipment—Bd. of Awards, Baltimore, Md., will receive bids until Mar. 14 for pumping equipment for Guilford pumping station and Montebello filtration plant.

Pumping Units—Dept. of Water Supply, Detroit, Mich., is receiving bids for one 200 m.g.d. and one 260 m.g.d. motor driven centrifugal pumping units for auxiliary low lift pumping plant at Waterworks Park.

Pumps, Etc. — T. M. Nichols, Mayor, Silverton, Tex., will receive bids until Mar. 15 for one 100 g.p.m. double stroke totally enclosed pluner type motor driven well pump against a 200 ft. head and one 500 g.p.m. motor driven centrifugal pump against 150 ft. head, 3 ph. 60 cycle 2,300 v., for proposed waterworks system.

Pumps, Etc.—Western Public Service Co., c/o C. Ely, Supt., Alvin, Tex., is receiving bids for two 250 and one 500 g.p.m. centrifugal pumps, etc. for proposed waterworks improvements. Private plans.

Pumps and Motors—City of Lone Wolf, Okla., plans to purchase centrifugal pumps and motors for proposed waterworks improvements. Estimated cost $35,000.

Pumps, Motors, etc.—R. R. Blankenship, Clk., Brock, Neb., will receive bids until Mar. 16 for one 60 g.p.m. single stroke pump, one 7½ hp. 3 ph. 60 cycle, 220 v. motor, etc., for proposed waterworks improvements. Estimated cost $21,330.

Pumps, Motors, Etc.—Bd. of Water Comrs., R. M. Roper, Secy., 436 Main St., East Orange, N. J., will receive bids until Mar. 8 for pumps, motors and necessary controls for Slough Brook Wells, 1, 2 and 3.

Refrigeration Equipment, Etc.—Silverwoods Ltd., A. E. Silverwood, mgr. London, Ont., has taken over the Cayuga Creamery at Cayuga, Ont., and plans the installation of refrigeration equipment, etc. to cost $25,000.

Turbine, Condenser, Etc.—Bd. of Works, W. O. Rhoton, Chn., Anderson, Ind., will receive bids until Mar. 15 for a 2,500 or 10,000 kw. turbine, condenser, and other equipment for light plant, estimated cost $150,000.